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PREFACE

Studies on growth and development of children were persued on Indian population by the Indian Council of Medical Research in 1950s. This project did not cover some of the areas in the country. The largest area that remained uncovered included the States east of Uttar Pradesh. Since I set out to work, I began to nourish the faint hope that it might one day be possible to cover those states left out by the I. C. M. R. Eventually, my own study had to be restricted to a small corner and to specific details only. And this book is a record of some aspects of growth and development of Calcutta girls, whom I was finally able to study.

The data for this study were collected from January 1966 to January 1968, though the period of time for the entire study including preparations extended from July 1965 to July 1968. The University Grants Commission offered me a fellowship and contingency grant for these years. This study may be considered as a pilot one to satisfy the need for a height-weight-age standard of the Bengalee girls. It must be confessed that the girls below 8.5 years could not be included in it due to time restraint, and as such, the entire picture of the growth of the girls from birth to maturity is yet to be fulfilled.

I am most thankful to the Anthropological Survey of India for publishing this material. I had to omit some of the original discussions and figures comparing with other studies. This had to be done to facilitate the publication. To my beloved husband, Late Dr. D. K. Sen, former Director of the Anthropological Survey of India, I owe much more than I could mention. He encouraged me all along the period of the study. No less grateful I am to my subjects for their cooperation. Finally, I hope that the present growth study would help in stimulating many more studies in this line. This I shall consider for me, the greatest reward.

CONTENTS

INTRODUCTION

Being born, growing to maturity, having progeny, then dying are the fundamental stages of life in plant, animal and man alike. Of these stages 'growth and development occupies a central place in the study of the mechanisms of evolutionary change, and central place also in the study of individual differences in the structure and function within the human species' (Tanner, 1960). The period of growth, as Tanner (1962) states, occupies more than a quarter of a person's lifetime. Searches for the patterns of changes in man's body structure and functions, both external and internal, have been going on for the last two hundred years or so.

Distinguished workers in this field entertian different conceptions. Brody (1945) states, "Growth is biologic synthesis, production of new biochemical units. It is the aspect of development concerned with increase in living substance or protoplasm and includes one or all of these processes (1) cell multiplication (2) cell enlargement (3) incorporation of material from the environment." The third process in Brody's definition means the inclusion of non-protoplas mic substances like fat, blood plasma, cartilage, etc., in the body ; it is not a 'true' growth but a part of the growth process. Berrill (1955), while discussing about growth, says, "The size that any organism finally attains is the result of growth and the regulation of size is essentially a matter of rate and duration of growth." He continues : "Growth and therefore size regulation, is associated with all things living, from sub-microscopical molecular components of a cell to the giant organismal whales and redwoods... The basic phenomenon of growing to a limited size is a general characteristic of organisms and their parts." This is determined genetically in the species and in general not subject to experimental modification, other than a degree of stunting through some form of malnutrition. Berrill states that it is difficult to ascertain when growth ceases to be maximal.

Weiss (1949) says that 'growth' is not a scientific term ; 'it has come to connote all and any of these, reproduction, increase in dimensions, linear increase, gain in weight, gain in organic mass, cell multiplication, mitosis, cell migration, protein synthesis and perhaps more.'

Needham (1933) subdivides growth into three headings or processes which are involved in it : (1) cell multiplication ; (2) intussusception, or increase in size of cells ; and (3) accretion or increase in amount of non-living structural matter. According to him, growth is differentiated into (1) increase in number of kinds of cells ; and (2) increase in morphological heterogeneity ; and growth involves metabolism which he classifies as respiration or oxidation, fermentation or glycolysis, catabolism of protein, catabolism of fat and chemical activity, as pigment formation, glycogen synthesis and so on.

population can be found out more conveniently by cross-sectional studies. Together with the mean, the standard deviation and standard error give a picture of the achievements for the population as a whole. Israelsohn (1960)) is of opinion that 'cross-sectional methods are adequate for studying distributions of various measurements in different individuals at different ages and for constructing standards of growth attained, e.g., height and weight standards. In these circumstances the relative case and rapidity with which results may be obtained from a large number of cases make the cross-sectional method preferable to the longitudinal one.' The longitudinal method, apart from being expensive and time-consuming, involves the co-operation of the subjects and their guardians which are absolutely indispensable. Many a longitudinal study for this reason has failed to be a pure one. Often they are mixed longitudinal, i.e., partly cross-sectional, as some subjects drop off and some new ones are added. Even the pure longitudinal data are treated as cross-sectional to arrive at the average velocities, and as Israelsohn (1960) says, they are poor representation of the population. This drawback of the longitudinal study was also realised by Boas (1892). Bryan and Greenberg (1952) have shown how important the cross-sectional study is for statistical method in estimating the importance of socio-economic background in growth.

The growth process is a sequential one ; after the primary and secondary centres of ossification of the cartilagenous areas appear the vascular penetration starts which leads to fresh deposit of bony tissues. This ossification acts in two directions, thickening and lengthening of the bones. With the completion of ossification bony growth stops, or in other words, maturation of the skeleton is achieved. The rate at which this system acts is dependent on many factors, primarily by genes (Buschke, 1934 ; Reynolds, 1943 ; Sontag and Reynolds, 1944 ; Garn, 1956 ; Falkner, 1958) and secondarily, by environment. Greulich (1941) is of opinion that heredity not only determines the 'end product of development but also prescribes quite definitely the stages to be followed in attaining that end.' Tanner (1962) states that there are differences in the rate of growth and development and it is presumably genetical in origin as studies from Africa and Western world prove. For this very reason Greulich (1941) proposes that studies on growth should be carried out in different populations, and the height and weight standards of one country are not applicable to another. That the rate of development is genetically controlled is fairly established. The age at menarche, a clear indicator of the onset of puberty, is mainly based on heredity. The studies by Bolk (1923), Gould and Gould (1932) show the similarity in menarcheal age in mothers and daughters ; Boas (1932) and Raymert and Jost (1947) show its likeness between sisters, and a very high correlation between identical twins has been proved (Tanner, 1962). Lintz and Markow (1923) say, "It seems to us that heredity plays a very important role, which is tantamount to saying that the incretory organs are the underlying factors in the determination of puberty." Environmental factors include climate and socio-economic condition which are manifested mainly in the dietary habits of a population.

Climatic effect on growth and development has been recognised by some workers. Mills (1937) is of opinion that sexual maturity in tropical countries comes two years later than in the

temperature regions. Kralj-Cereck (1956) holds the view that the age at menarche is greatly dependent on genetic, climatic and geographical location plus social and environmental factors. On the other hand Lintz and Markow (1923) and Ellis (1950) vehemently oppose the views shared by Mills and Kralj-Cereck ; according to them, environment has less to do with the onset of menstruation than is generally supposed.

The positive influence of food on the rate of growth and development has been shown with more success by many authors. Kralj-Cereck (1956) shows that mainly protein-eating girls have earlier menarcheal age than the mixed or carbohydrate eaters and this difference has been statistically proved as significant. That the normal rate of growth has been retarded by underfeeding and can be restored by adequate supply of food has been proved by Schloss (1911), Boas (1912) and Goldstein (1922). In recent years a number of studies have been made in western countries and in Japan to show that the war effect (malnutrition) has hampered the growth of children (Ellis, 1945 ; Howe and Schiller, 1952 ; Markowitz, 1955 ; Bolsakova, 1958 ; Kimura *et al.*, 1959). Acheson (1960) says that continued environmental adversity induces stunted growth. But if the adversity is not a prolonged one the hampered rate of growth is made up and the ultimate skeletal maturation is not significantly affected. Tanner (1962) states 'so far as can be ascertained from present data neither climate nor race influences the time of adolescence as greatly as does nutrition.' What is true for the adolescent period has been shown to be true for the entire growth period. "... recent advances on endocrinology revealed that various steroid hormones have significant bearing on the development of the body and constitution" (Matsumoto *et al.*, 1962). After the baby is born adrenal androgen continues to exercise influence on its growth and development. This hormone induces changes in musculature, bones, skin, genital structure and larynx (Talbot, 1952). It leads to accelerated growth in stature, skeletal maturation and appearance of secondary sexual features like pubic and axillary hair, acne, and deep voice in boys. Pituitary growth hormone induces symmetrical growth of skeleton, muscles and splanchnic organs, or in other words, general somatic growth. The thyroid stimulating hormone (TSH) induces development in thyroid gland, its production and secretion, which in its way may influence the production of pituitary stimulating hormone (PSH). If the TSH produced is less than adequate, it affects the PSH production as well. The anterior pituitary gland produces gonadotropin which in its turn influences the function of ovaries and testes producing estrogen and androgen respectively. The estrogen and 17 ketosteroids influence the process of sexual maturation in girls (Seward, 1946 ; Matsumoto *et al.*, 1962). Prolonged period of inadequate dietary intake may result in the decreased pituitary activity and ultimately in retarded growth in height, lack of subcutaneous tissue deposit and retarded skeletal and sexual maturation (Talbot, 1952). But it is not easily made out whether the short stature of an individual is due to heredity or to hypopituitarism.

Though endocrinologists have contributed much to the understanding of the mechanism of 'growing' they are not able to explain the differences existing in this phenomenon from

one population to another. This perhaps takes us back to the importance of heredity and environment in influencing growth and development.

Growth studies in Western countries have been conducted and are being conducted at many places, on many communities. But there are very few such studies on the Asiatic or African populations. The Indian Council of Medical Research carried out a study on the physical growth of the children in the northern, central and southern zones of India. The findings of this study are still unpublished. The eastern part of the country has not been touched by the I.C.M.R. As the population of India is a heterogeneous amalgam of different ethnic elements the proportions of which vary from one zone to another, the necessity of undertaking a growth study in West Bengal is strongly felt. The present study, it must be admitted, is far from fulfilling the want. However, in spite of its limitations, this study may prove a step forward in fulfilling the need. The data have been collected from the city of Calcutta, on more precisely, the southern part of it.

Situation and climate of Calcutta

Calcutta, a metropolitan city, is the capital of the State of West Bengal. It is situated at 22.32° North latitude and 88.20° East longitude. The altitude of Calcutta is 21′ above sea level. The mean annual temperature is 27.2° centigrade. The mean rainfall is 1438 millimeter (between 1952 and 1961) and the average humidity is 75%, the range being 68% to 85%. The average number of rainy days is 84.3. The area of the city, including greater Calcutta, is 32.32 square miles.

Population

The Census report of 1951 shows the population figure as 2, 548, 677 of which 925, 466 were females. The density of population per square mile was 78,858 persons. In the municipal area of Calcutta the number of females between the ages five and twentyfive was 429.8 thousand.

These figures include, besides Bengalees, people from other States residing temporarily (at least for the last 3 years) or permanently in the city and also a number of foreigners.

The total population of Calcutta in the year 1961 was 2,927,289 according to the statistical Bureau, 1961.

The literacy rate in Calcutta in 1961 was 63.6% among the males and 52.3% among the females.

Health

Calcutta is a hotbed of infectious diseases. The figures for total number of deaths from vari-

ous epidemic diseases, given by the Statistical Bureau, 1961 were :

Cholera	1,970
Small pox	592
Malaria	3,075

Another very common disease in Calcutta is dysentery. In many families there are patients suffering from this disease, but no figure is available on the morbidity or mortality from dysentery.

The city of Calcutta is under the food rationing system from the year 1943 when each person was given 3.27 kg. of cereals per week. In 1966 the quota of cereals was reduced to 2 kg per adult.

justification of the measurements and observations taken for the study

Garn (1957) calls the statural growth in man a "summation" of the general growth. Similarly, body weight also sums up the result of all increments (Vickers and Stuart, 1943). Stature and weight have been the two most common and important measurements for the studies in growth throughout the world. But body weight takes into account all the soft and bony parts of the body. When a change occurs in the weight for height it is necessary to find out which tissues are responsible for this change. And in this quest some other measurements become indispensable. Stuart and Meredith (1946) recommend pelvic breadth and chest circumference 'to supplement height in evaluating skeletal size and build.' To find out the size of the muscles 'both for its own right and for its proportionate influence on body weight' the same authors recommend circumference of calf to be included to a minimal list of measurements as the shaft of tibia and fibula have very small influence on this measurement and is mainly dictated by the muscles and fat. The fat in this part can be measured by a skinfold calliper in lieu of X-ray. Measurement of the subcutaneous tissue is also important in order to find out, primarily, the nutritional condition, and secondarily, the type of build or constitution.

According to Stuart and Meredith (1946), the school health programme should include the height, weight, hip width, chest circumference, leg girth and two selective folds of subcutaneous tissue and skin, as the minimum routine for evaluation of physical status and physical progress in relation to age. Stuart *et al.* (1946) in their review of the growth studies from a number of centres in the United States picked up weight, height, sitting height, shoulder breadth, pelvic breadth, hip bredth and thoracic circumference as the common measurements taken in those studies. In the present investigation these measurements have been included. Ohlson *et al,* (1956) took stature, weight, chest diameters, arm girth, calf girth and bi-iliac diameter for the purpose of determining the nutritional status of women. Further, as nutrition is one of the major factors in growth, the mesurements of arm girth and calf girth, as suggested by Ohlson *et al,* are worthy of inclusion in growth studies. So, these also have been added to the

list. Here it should be mentioned that the anterio-posterior diameter of chest of the Bengalee girls of post-puberty group is not possible to measure due to the resistance offered by them. As a consequence only the lateral diameter has been included in the proforma.

Besides the above mentioned measurements, the hight acromion, height dactylion and sitting height are included in the study to arrive at the rate of growth of the upper and lower limbs. Fat deposits at three most easily accessible sites have been taken and these could be compared with other studeis from outside India. Fry *et al.* (1965) took skinfold measurements in the regions of triceps, calf, subscapular and supra-iliac ; on the ground of easy access the first three of these sites have been included in the present study. The menarcheal age is the only criterion of puberty taken into account. The different stages of deve lopment of breast and pubic and axillary hair could not be studied in the present sample for obvious reasons. The teeth have been observed for their eruption. Kraus and Furr (1953) stated, "Because of their peculiar sequence and time of eruption, the teeth serve as convenient markers for stages of growth." The eruption of teeth, according to them, is influenced by heredity and it manifests certain stages of physiologic disequilibrium. According to Tanner (1952), teeth may serve as indicators of skeletal development. As no X-ray could be taken on the subjects of the present sample due to lack of financial assistance, the time of eruption of teeth was thought to be worth a prove. Krogman (1951) suggested the inclusion of tooth eruption sequence in growth studies to find out the racial difference.

Some other information collected from the subjects as regards their socioeconomic background have not been dealt with in the analysis. In future this information may be utilized in further studies.

MATERIALS AND METHOD

Materials

The data for this cross-sectional study on the growth and development of the Bengalee girls were collected from January 1966 to January 1967. In all, 2536 girls were measured from some educational institutions of Calcutta, mainly located in the southern part of the city. Many institutions were approached. But only those institutions were selected wherever co-operation from the authorities was available. These schools and colleges are either private, government aided or purely government organisations. No municipal school where education is free and where the poorer children attend, was included in the study. An attempt has been made to include the institutions charging high and low tuition fees where the children of well-to-do and comparatively poor parents respectively attend. The parents of these girls are teachers, government servants, employees of private organisations, or in business, and all are educated.

In all, eight schools and eight colleges were visited. From every school 25 girls from each class were measured so that the target of 200 subjects in each age group is represented by the different schools. While the school girls were much enthusiastic and much co-operative in this work, the college girls in general were quite otherwise. Lack of co-operation from the college girls resulted in the failure to study the required quota of 25 girls from each class of the colleges. As a result, wherever the authority of any college showed active interest, as the Principal of the Lady Brabourne College, more than the required number of the quota for that institution were measured.

Table I gives the tuition fees and the number of girls measured in the institutions. The tuition fees shown in the table is for the topmost class (XI) for students of Humanities group in the schools, and for the students in Humanities group for degree classes in the colleges. It may be noted that except the South Point School and the St. John's Diocesan Girl's High School the fees vary very little. Kamala Chatterjee School charges the minimum. Loreto Convent College charges the highest amongst the colleges and Jogamaya Debi College for Women the lowest. Girls from Loreto college are from perceptibly better-off homes, but students of Jogamaya Debi College come from similar economic class as the students from any other colleges.

Each girl measured was given a printed form to take home and she was asked to get the form filled in by the guardian. Whenever a boarder was measured she was given time to get the

Table I : Number of girls measured from different institutions

Educational institution	Monthly tuition fees in rupees	No. of girls measured
Schools		
1. Childrens Sweet Home	14.00	171
2. Chittaranjan Girls'	12.00	166
3. Kamala Girls'	11.00	87
4. Kamala Chatterjee Girls'	8.00	48
5. Lake Girls'	10.00	376
6. Sir Romesh Mitter Girls'	14.00	428
7. South Point	25.00	181
8. St. John's Diocesan	20.00	155
Colleges		
1. Basanti Debi	12.00	72
2. Jogamaya Debi	8.00	125
3. Lady Brabourne	10.00	237
4. Loreto Convent	35.00	41
5. Muralidhar	11.00	76
6. Shivnath Shastri	11.00	179
7. South Calcutta	12.00	149
8. University Science (Post-Graduate)	15.00	45
Total		2536

information necessary from home if she was not able to supply them herself. The girls were requested to get the blank for diet for one whole week to be filled in; in the blank an approximation of the quantity of food taken under each item was also asked for. Nearly 25% of the forms were returned, but of these 22% gave the income and the number of family members in the household. As a consequence, the monthly per capita income of the families of only 563 girls could be calculated. The response on the item of diet was still less. So diet was not taken into account in this study as was originally intended. The school girls, again, were much more co-operative than the college girls in furnishing the answers for the second form.

The monthly per capita income of the families of 563 girls, which is a sub-sample of the series, is shown in Table II. It can be seen that nearly 90% have a per capita income not exceeding 300.00 rupees; only 10% have a higher income than this, while the maximum number (56.84%) come from families with a per capita income of not more than 100.00 rupees.

Table II : Frequency and percentage distribution of per capita income

Income per capita, in rupees	Number of subjects	Per cent of total 563
X - 100	320	56.84
101 - 200	128	22.73
201 - 300	62	11.01
301 - 400	19	3.38
401 - 500	17	3.02
501 - X	17	3.02
Total	563	100

As can be seen from the above table, the distribution of income is not "normal". So the mean of this series will not give a true picture. As the higher-income groups, having a per capita income of Rs. 301.00 and above, constitute only 10% of the sample, they have not been treated separately in the calculations for different variables. The minimum age of the girls measured is 8 years and six months. Girls of lower age than this were not taken as they were not thought to be old enough to take care of the forms and furnish the required information. Their ages also were difficult to obtain from them. Moreover, the girls in primary classes are generally above eight years of age. To obtain the data from girls age 8 years and below, kindergarten schools would have to be visited and would have taken much more time. The girls are from ages 8.5 years through 27.5 years. But the data from the age groups above 21.5 are small; 35 girls belong to the ages 21.5 to 27.5 years and 88 girls from 20.5 to 21.5 years. These two series have been lumped in one 20+ group for the sake of convenience in calculation.

Table III shows the frequency distribution of the number of girls in each age-group. The age was calculated to the nearest month from the date of birth and the date on which the measurement was taken. More than 15 days was taken as the next month; thus 9 years 6 months 16 days was taken as 9 years 7 months which was ultimately grouped as 10 years.

The Muslim, the Christian and many castes among the Hindus were included in the study as "Bengalee", but the number of Muslim or Christian girls measured was much less than that

of the Hindus. Girls of mixed parentage, like Bengalee and foreigner or Bengalee and person from other Province, were excluded. Except for a very few, most of the girls in this sample were born and brought up in Calcutta proper or in greater Calcutta. Care was taken to choose physically normal girls. Those who looked perceptibly emaciated and who looked ill or unhealthy were omitted. A close watch was kept on the gait and walk of the subject, and if any abnormality such as a perceptible tilt in the pelvis or a limp was noticed, she was rejected. Not to hurt the feelings of these handicapped girls the measurements on them were taken as usual and later on, discarded. All the girls, that is to say, the selected ones were those who ranked as normal.

Table III : Frequency distribution of girls by age-group

Age in years	Range (in years)		No. of girls
9	8.5 - 9.5		34
10	9.5 - 10.5		193
11	10.5 - 11.5		198
12	11.5 - 12.5		181
13	12.5 - 13.5		199
14	13.5 - 14.5		215
15	14.5 - 15.5		215
16	15.5 - 16.5		290
17	16.5 - 17.5		236
18	17.5 - 18.5		263
19	18.5 - 19.5		226
20	19.5 - 20.5		163
20 +	20.5 - 21.5	88	123
	21.5 - 22.5	16	
	22.5 - 23.5	10	
	23.5 - 24.5	3	
	24.5 - 25.5	1	
	25.5 - 26.5	2	
	26.5 - 27.5	3	
		Total	2536

Method

Menarcheal age

In order to ascertain the mean age at menarche all the girls were interrogated individually. The older subjects were asked to tell about the age at which they first menstruated. But such

questions were obviously somewhat embarrassing when put to younger subjects. They were, therefore, first asked whether they menstruated at all. If they answered in the negative or gave a blank look indicating that they did not know about the phenomenon, no further probe was made and they were registered as non-menstruators. Those who answered in the affirmative were helped to remember, as far as possible, the exact month and date of the commencement of menarche.

Quite often the girls were not able to state the year straight away, they were given time to remember the class in which she was studying at the time of menarche. There was hardly any difficulty in recollecting this. The class was noted and the year found out. She was asked if she was detained in any class and the correction of the year was made accordingly. The next step was to find out the month and date of the menarche. For this more time was spent, the girl was helped with a leading question like "was it summer," "was it winter", or "was it during the summer holidays or *pujah* holidays (in October generally)", or "did you have any examination at hand or was it after the examination." These questions produced satisfying results. Most often they would suddenly remember the date and almost all could tell the month. While some girls were ready to give year, month and date straight away, others could state their age at menarche or only the year. Menarche is an important event in the life of a girl. Once she overcomes the initial shyness she would be ready with the replies. Some patience was of course necessary for this on the part of the investigator.

Lengths

1. *Stature* (*height vertex*) : The subject was made to stand free and away from the wall as is recommended by Krogman (1948). This procedure allows the investigator to go round the subject and to conveniently take the other measurements included in this study. Her shoes were removed from the feet of the subject before taking the measurement, while her socks, if nylon or cotton, were not removed. The subject was made to stand erect with her eyes directed towards the horizon, the lower surface of her chin parallel to the ground, her heels together and big toes apart making an angle of about 45° and her arms hanging at the sides (thumbs forward). The anthropometer was held parallel to the body, the base being kept in between the heels and touching them, the stem of the anthropometer touched the cleft between buttocks, the sliding sleeve was lowered down to touch the middle of the head (sagittal line) lightly and the reading in centimeter and its fraction was recorded. Care was taken to undo the bun of the hair if it came in the way of the anthropometer touching the back of the head.

2. *Height acromion* : The subject was kept standing in the same posture after taking the height, the anthropometer was brought to the right side of the subject, the tip of the sliding sleeve was made to touch the acromion (the most lateral point on the acromion process of the scapula found by palpating with the finger) and the reading recorded.

3. *Height dactylion* : The subject standing in the same erect posture and the anthropometer kept at the same place as for the previous measurement dactylion (tip of the middle finger) of the right hand was touched by the tip of the sliding sleeve for this reading.

4. *Sitting height* : The subject was made to sit on a stool or a flat wooden chair or at the end of an wooden bench (whichever was available at the place of measurement) in an erect position, thighs horizontal and legs vertical, feet just resting on the floor, the subject sat well backwards so that the dorsal surfaces of the knees were touching the edge of the seat. When a subject slumped a pat was given at her back to straighten up the back so that the lumbar curve looked concave and the spine flexed. The anthropometer was brought close to the buttock touching but not pressing it, and it was made to touch the back of the head keeping it vertical and parallel to the body of the subject. The sliding sleeve was brought down to touch the vertex for recording the measurement.

5. *Arm length or length of the upper limb* : The reading for dactylion height was subtracted from the reading for height acromion for each individual to find out this measurement. This measurement includes the length of the upper and lower arm plus the length of the hand.

6. *Leg length or length of the lower limb* : The reading for stature was subtracted from that for sitting height. This measurement is recommended by Hooton (1949) who says, "Subtracted from stature it gives the best approximation of total length of the lower extremities."

Diameters

1. *Bi-acromial* : The maximum breadth of bony shoulder taken from acromion to acromion. While the subject stood erect with arms hanging to the sides the measurement was taken from the back, palpating the acromia with the index fingers.

2. *Chest breadth* : This measurement was taken standing at the back of the subject. The subject was made to stand erect (as for stature) with arms hanging but slightly away from the body. The arms of the anthropometer touched the sides of the chest at about the level of the fourth pair of ribs. Whenever some bulging was found at this level due to tight brassiere or blouse, they were unhooked and there was some waiting for the bulge to subside. The subject was told to breathe normally.

3. *Bi-iliac breadth* : This measurement was also taken from the back. Undergarments, if gathered on the iliac crests were lowered down a little so that not much cloth came in the way. Pressure was applied on the arms of the sliding callipers (upper segment of the anthropometer) to reach the lateral margins of the iliac crests as close as possible.

Girths

1. *Chest* : This measurement was taken from the front at the level of the fourth pair of ribs

with a steel tape graduated in centimeters and millimeters. Tight brassieres and blouses were unhooked for this measurement. The reading was taken in between inhalation and exhalation.

2. *Upper arm* : The measurement was taken with a steel tape at the middle (midway between acromion and elbow) part of the left upper arm, on naked skin.

3. *Calf* : This measurement was also taken with a steel tape. The maximum breadth on the calf was taken into account. The left foot of the subject was made to rest on a stool, and care was taken to ensure that the muscle was completely relaxed. No pressure was applied on the calf.

Skinfold pinches

For measuring the subcutaneous tissue of the girls in this sample the skinfold callipers made by Messrs John Bull, Great Britain, were used. The callipers were checked by a pressure gauge from time to time for accuracy of the pressure applied by the spring. It exerts a constant pressure of 10 gm/mm^2 on the jaw surface ; each jaw measures 6 mm in width and 15 mm in length. Readings were taken to the nearest 0.1 mm as prescribed by Tanner (1962).

The three regions chosen for measuring the sub-cutaneous tissue are readily accessible. Still, a great deal of unwillingness from the subjects was faced. It is well known that the oriental girls are shy. For this reason no attempt was made to measure skinfold in any other regions besides the subscapular, upper arm and calf.

Subscapular skinfold

It was taken just below the inferior angle of the left scapula and at a variable angle of up to 30° from vertical following Langer's line.

Upper arm or triceps

The pinch was taken on the middle of the upper arm (where the girth was taken) half way between the acromion and the elbow and parallel to the long axis of the arm.

Calf

At the level where the girth was taken, i.e., the greatest circumference of the calf, on the line with the lateral malleolus and parallel to the long axis of the leg.

Weight

The weight was taken on a spring machine manufactured by Messrs Krups of Germany and

graduated in kilograms and pounds. In the scale a kilogram was divided in ten divisions, and a pound in eight divisions. The weighing machine was checked from time to time with a known weight. Care was taken to place the machine on a plain surface. The girls were weighed before the lunch break. The weight was recorded to the one-tenth of a kilogram. No deduction for the weight of the garment (less than a pound on the average) was made from the reading for the final weight.

The teeth

The eruption of various teeth of the permanent set in both the upper and the lower jaw was noted. The "eruption" of a tooth means, for the present study, emergence of the crown through the gum to any degree. Persistence of any milk tooth abnormal for the age was also recorded. Other anomalies, like the presence of milk and permanent set of the same tooth were noted.

Statistical analysis

Simple statistical analysis of the data on the present sample has been made. It includes mean, standard deviation, and standard error of the mean for each dimension of each age group. The difference between means of one age group and the next is arrived at by subtracting the mean of the former from the latter. The growth curve for each dimension is drawn by plotting the means against the respective ages. The velocity curves for the dimensions are based on the difference of means plotted against the age intervals.

Whenever the frequency distribution for any dimension was not found to lie in normal curve, logarithmic transforms of readings were used for the statistical analysis, and the curves for growth and velocity were based on these log transforms. The weight and skinfold measurements were converted into logarithmic values. The skinfold measurements were converted into log units by using the formula $100 \times \log_{10}$ (reading in .1 mm—18) as prescribed by Edwards *et al.* (1955).

The adolescence spurt in growth has been discussed on the basis of the maximum value of standard deviation as recommended by Burgess (1937). The velocity curve has also been taken into account, though in a lesser degree, for finding out the spurt at adolescence. The regression equation, $y = bx + c$, has been used for showing the relationship between stature and weight. The log weight has been used for the calculation of this equation. The means of the direct readings for stature and of log weight give the best estimation of the relationship between these two measurements as shown by Hierneaux (1962).

The comparison with other studies on various dimensions is based on the growth, velocity and standard deviation curves. Unfortunately, standard deviations have not been reported by many authors. Therefore, it has not always been possible to compare the adolescent spurt on such cases in the present study.

Besides the usual statistical analysis followed for other dimensions, percentage distributions have been calculated for the age at eruption of various teeth and menarche.

Indices have been calculated for various paired dimensions to show the relative growth of one in terms of the percentage of another as age progresses. Besides the indices, the growth of one dimension in relation to another irrespective of age is shown in figures where the means of one dimension have been plotted against those of the other and the line joining the points drawn by eye estimation following the least square method. Hierneaux (1968) advocated this system for showing the relationship between any two dimensions.

AGE AT MENARCHE

All the girls in this sample numbering 2536 were interrogated to ascertain the age at menarche. Of the whole sample, 25 girls of age groups between 17 and 20+ years could not remember or did not volunteer to give the information. These 25 girls were excluded while calculating the mean menarcheal age. In all, 1837 girls in this sample were menstruating and they belonged to the ages 10 through 20+ years. Out of 1837 girls, 1764 could tell the year and month of menarche. Of these, 1100 girls could furnish the date as well. Only 73 girls could not remember beyond the year of the onset of the phenomenon.

The mean menarcheal age of 1837 Bengalee girls is 12.48 $\pm$ .03 years S. D. 1.27 years. The range lies between 8 years and 17 years; the frequency for these two age groups is 1 each. Table IV shows the frequency distribution of the remembered menarcheal age.

Table IV : The frequency distribution of age at menarche remembered by 1837 Bengalee girls

Age in years (mid-point)		Frequency
8		1
9		20
10		77
11		261
12		616
13		489
14		262
15		100
16		10
17		1
	Total	1837

The number and the percentage distribution of the girls who reported to have experienced menarche are given in Table V against their respective age groups.

Table V : Number and percentage distribution of girls menstruating according to their age groups

Age in years (mid-point)	Total number	Number menstruating	Percentage
9	34	0	0
10	193	3	1.55
11	198	17	8.58
12	181	68	37.57
13	199	151	75.88
14	215	203	94.60
15	215	210	97.67
16	290	288	99.31
17	236	236	100
Total	1761	1176	

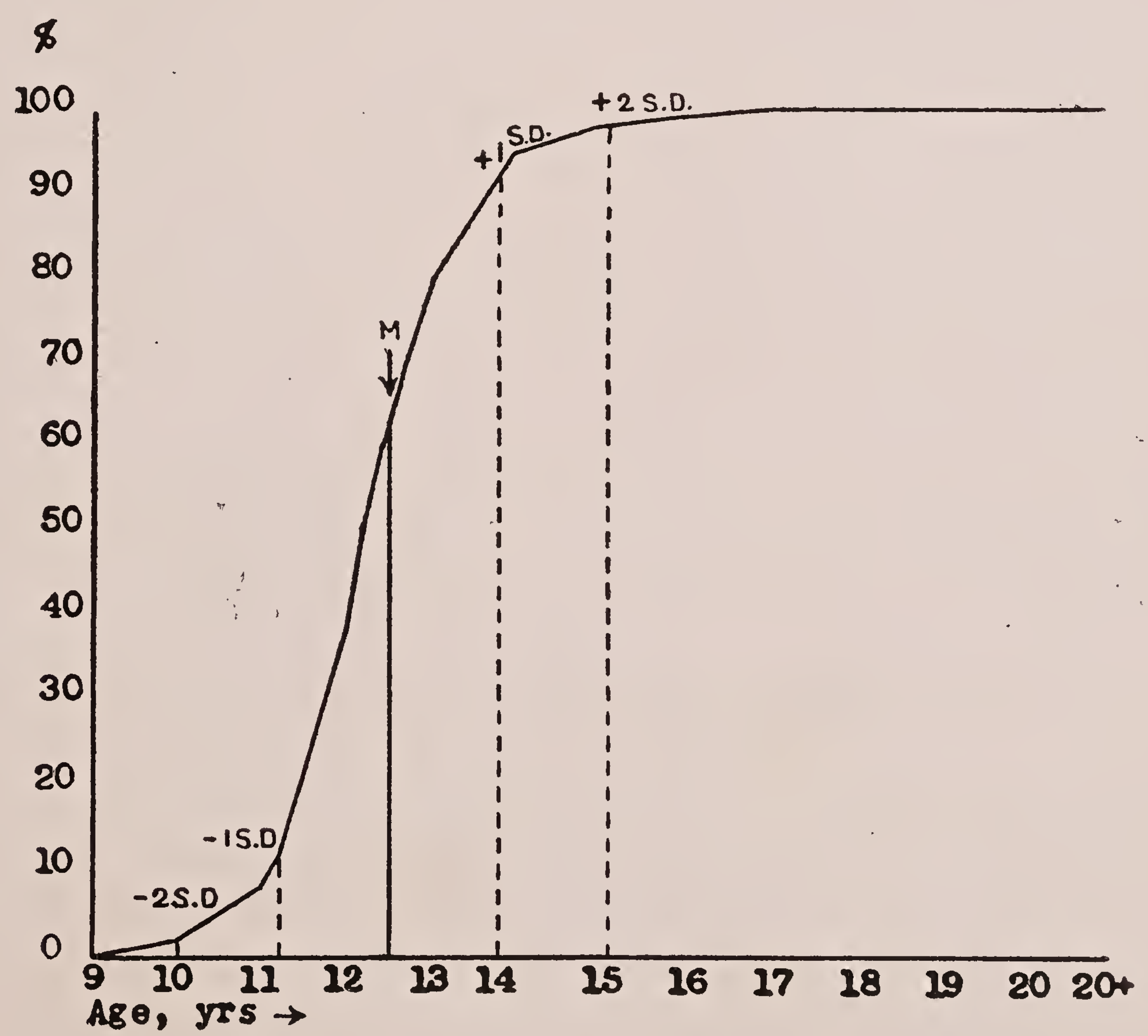


Fig. 1. Percentage of girls menstruating in each age group with mean (M) ± 1 and ± 2 standard deviation (S.D.) of remembered menarcheal age for the sample.

It may be seen from the table that no girl from the age group of 9 years yet experienced menarche and only 3 out of 193 girls in the 10-year age group experienced it. By 15 years of age nearly 98% of the girls in that group menstruated and by the age of 17 years all girls were menstruating. These percentage distributions according to age together with the mean, ± 1 and ± 2 standard deviation of the menarcheal age, calculated for 1837 girls of this sample are shown in Figure 1.

The Bengalee girls interrogated in 1950-51 are reported to have a mean menarcheal age of 12.78 ± 0.05 years and S. D. 1.27 years, the total number being 647 drawn from only three Hindu upper castes (Sen, 1953). The present sample deals with the girls of all castes. The difference between these two mean ages is 0.3 years, i.e., menarche occurs 3.6 months earlier in the present sample. The former sample included women old and young, though the majority of them were school girls. Except the two extreme cases in the present sample where menarche occurred at 8 and 17 years, in both the series the frequencies lie between 9 and 16 years of age. Gupta (1848) studied 37 women from Bengal and found the mean menarcheal age as 12.3 years, which is 0.2 year or 2.4 months earlier than in the present sample.

Robertson (1845) published his paper at about the same time as Gupta on the menarcheal age of women of Calcutta—apparently Bengalee women, numbering 90 and the mean menarcheal age found was 12.4 years. His second paper (1846) gives the age as 13 years 5 months and 24 days, the total number of subjects being 230. These two papers published within a year show a major variation in the value. The one mentioned first comes close to the present finding.

Curjel (1920) collected data from 545 Calcutta women and found the menarcheal age of the Hindus (N = 268) to be 13.62 years, S. D. 1.80 years. This age is higher than that reported by Gupta, Robertson and the present investigator.

Banerjee and Mukherjee (1961) find the average menarcheal age of 1047 Bengalee women who came to their clinics to be 13.60 years with S. D. 1.80 years, the range being 9 to 19 years. This mean is also quite high compared to that for the present sample.

The values of 't' calculated for the differences in mean menarcheal age between the present sample and the former ones from Bengal discussed so far, show (Table VI) significant difference. These differences are significant at 1% level of probability. The probable explanation of these differences seems to be that the samples in the former studies included women of older age groups while the present sample consists of younger girls. Of the total number (1837) of girls menstruating in the present sample and on whom the mean age had been calculated, 1439 girls were within 18.5 years of age at the time of investigation. This gives a percentage of 78.33 of the total and leaves only 21.67% of the total belonging to the ages 19 years and above. The former study on the girls from Calcutta by the same author (Sen, 1953) included a large number of young girls also, but still 216 girls out of 647 (or 33.38% of the total) belonged to an

age higher than 18 years. This percentage of older girls is somewhat higher than that in the present sample. Curjel as well as Banerjee and Mukherjee had presumably collected data from older females than the present or former series of mine. These authors had collected the data on menarcheal age from the patients in hospitals or clinics, and usually older women go to the gynaecologists for complaints.

Bojlen and Bentzon (1968) have discussed the disadvantages of collecting data on menarcheal age from girls whose age is above 18 years. These authors found earlier (1954, 1964) 'the recollected age information had a systematic error...' and this error is ¼ to ½ year too high. Based on this assumption, the authors have corrected the age at menarche from different parts of world whenever the data came from women older than 18 years.

Table VI : The values of 't' for the menarcheal age between the present and past studies from Bengal

Authors	No.	Mean	S. D.	't' with present sample	Significant or not
Curjel (1920)	268	13.62	1.80	10.00	Significant*
Sen (1953)	647	12.78	1.27	5.172	„
Banerjee and Mukherjee (1961)	1047	13.60	1.47	23.364	„
Present sample (1966-1967)	1837	12.48	1.27		

*Significant at 1% level of probability

If the hypothesis is applied to the studies on menarcheal age from Calcutta, the significant difference found by 't' test between the present study and the past ones may be explained. However, from the existing knowledge on the age at menarche of the Bengalee girls, it appears that there has not been much of a change in the last hundred years. The reason may be sought in the static condition of their social and economic life as Bojlen and Bentzon suggest (ibid). It is perhaps clear that more data should be collected from school going Bengalee girls to obtain better estimates of the mean menarcheal age of the Bengalee women. This will help to determine the secular trend in their menarcheal age, if there is any.

The menarcheal age of the Assamese girls reported by Rakshit (1960) is 12.39 years. Her sample includes some castes of the Hindu community and some Muslims from Jorhat girls' High School. This mean age is similar to the mean age of the Bengalee girls of the present series. Foll (1961) gives the menarcheal age of the Assamese and the Burmese girls as 13.2 years which is higher than that in Rakshit's report or in the present series.

Rakshit (1962) in another paper shows the menarcheal age of the Maharastra Brahman women of Nagpur city under two different categories those who were married, between 1911-20

and those between 1921-30. If these two categories are combined the mean value comes to 14.38 for 77 women, which is higher than that in the present series.

Baxi (1957) has reported the average menarcheal age of 415 women who were the patients of Municipal General Hospital, Sion, Bombay to be 13.78 years with S. D. 1.6 years. Seetha (1957) gives the age of menarche of 100 Andhra women as 13.53 years. And Manuel (1957) reports the menarcheal age of 169 patients (Andhra women) of Christian Medical College Hospital, Vellore, in frequency distribution. The worked out mean of this sample is 14.75 years with S.D. 1.45. All these three papers were read at the Ninth All India Congress of Obstetrics and Gynaecology, 1956. The mean menarcheal ages in these three samples are higher than that in the present one.

Of the primitive tribes of India we have a report by Wilson and Sutherland (1950) on the menarcheal age of the Munda, the Oraon and the Santal women of Central India, numbering 411, the mean being 14.65 ± 1.55 years. This mean also is higher than that of the present sample.

In Uttar Pradesh, Dubey and Srivastava (1963) give the menarcheal age of the college girls of Lucknow as 13.57 ± 0.06 years, all groups combined, the total number being 361. They also give a mean of 13.62 ± 0.07 years for 253 Hindu girls (who are included in the larger sample). Both of these two means are higher than that of the Bengalees of the present series.

Madhavan (1965) collected data from 503 and 507 girls from the rural areas of Tamil Nadu and Kerala respectively, 381 from the city of Madras and 404 from Trivandrum. The urban girls come from high socio-economic group of the two cities mentioned, while the rural samples come from poor economic group. The girls belong to ages from 11 to 18 years. The meen menarcheal age of Madras urban girls is 12.76 years and that of the rural ones 14.16 years. For the urban girls of Kerala the mean age is 13.24 years and for the rural ones 14.42 years. It may be noted that in both the cases the urban girls menstruated earlier than the rural ones. The urban girls of Madras come closest to the Bengalee girls of the present sample in menarcheal age. The Nayar sample of Travancore numbering 44 reported by Sen (1953) gives the menarcheal age as 14.29 ± 0.19 years. This is, of course, much higher than that for the Bengalees.

Some Indian girls of Durban, South Africa, living in a very low socio-economic condition show the mean age at menarche to be 13.9 years (Kark, 1956).

Wilson and Sutherland (1950) give the age at menarche of the girls of rural areas of Sri Lanka as 14.4 years. This figure is similar to Madhavan's figure for rural areas of Tamil Nadu and Kerala but is higher than for the Bengalees.

Scarpo reported (1954) the menarcheal ages of the Indian (Tamil) women who had migrated to Sri Lanka and the Sri Lanka women. The mean menarcheal age of 451 Ceylonese women is 13 years 4 months with individual variations from 10 to 20 years, and the highest percentage

of 30 lies in the 13-year age group. Compared to them the Bengalee girls are about half a year advanced and the range is shorter ; their highest percentage lies in the 12-year age group. But the Tamil women in Sri Lanka in the above study show the menarcheal age as 13 years, the highest percentage lying in the 12-year age group. These Tamil women, therefore, stand closer to the Bengalees.

From China comes the report of Chau and Wright (1925) on 2291 South Chinese women living in subtropical Canton. Of them, about one-third comes from the rural and two-thirds from urban areas. The mean age of menarche of these women is 14.5 years. Over 90% of them menstruated between 11th and 17th years. Though the mean age of menarche of these Chinese women is higher than the Bengalees yet the range is similar in both. Mills and Ogle (1936) give the menarcheal age of 284 Hongkong Chinese as 15.82 ± 0.06 years. Preston (1957) finds this age for 99 Chinese women as 16.13 years with a range from 13 to 21 years. Mondiere (1880) gives the figure for 106 Chinese girls as 16 years 6 months and 62 Min-Houng girls as 16 years 9 months. All these studies give a much higher age at menarche (roughly about 3½ years) for the Chinese girls compared to the Bengalees of the present sample.

From other countries of Far East Asia come some reports which can be compared with the present sample. Mondiere (1880) gives the mean menarcheal age of 96 Cambodian women as 16 years 10 months and that of 980 Annamite women as 16 years 4 months. Both these figures are about 4 years higher than that of Bengalee girls. Mills and Ogle (1936) put the mean age of menarche of Manila Philipino unmarried women (N = 22) as 14.73 ± 0.16 years and for married women (N = 84) as 14.58 ± 0.12 years. Manila Philipinos, therefore, menstruate about 2 years later than the Bengalee girls. Zelisky (1948-50) determined the menarcheal age of town girls of Indo-China who originally came from the villages to be 16 years 3 months. The rural and urban girls combined show the age as 14 years 10 months. But these urban girls come from mixed parentage-French father and Indo-Chinese mother. For this study it is better to take the pure Indo-Chinese girls, though from rural areas, into account. The figure of 16 years 3 months is again much higher than that of the Bengalees. Wadsworth (1953) finds the age at menarche of the Chinese, the Eurasian, the Indian, the Indo-Chinese, and the Singapore women numbering 58 as 13.6 years. From all these studies of the Far Eastern countries it is apparent that the Bengalee girls reach their puberty from 2 to 4 years earlier. Matsumoto *et al* (1963) recorded the menarcheal age of 11354 Japanese girls of both rural and urban areas from all walks of life, collected between 1944 and 1961. Of these, the students of Tokyo city show the mean menarcheal age to be 13 years 4.9 months in 1953 and 12 years 9 months in 1961. If the latter figure is considered for comparison with the present sample there is a difference of about 3 months between the two, i.e., the Japanese girls are attaining puberty about 3 months later. Makuda and Hori (1939) give the menarcheal age of 411 Japanese girls as 14.8 years with a range from 11 to 20 years. Yamasaki (1909) gives the menarcheal age of the girls numbering 4861 from Japan as 14.8 years the range being 9 years to 21 years. Both of these studies show a higher age than that of the present sample.

Going over to Africa, we have the article of Kark (1943) who has reported the menarcheal age of 1038 Bantu women from various districts of Transvaal, Natal, Orange Free State and Cape Provinces. Of this sample only one girl had menarche before 13 years, 40.5% at 15, 80% at 16, and by 19 all had their menarche. Compared to this the present sample shows a much earlier date. Unfortunately, no mean age has been provided by Kark. Ellis (1950) has reported the menarcheal age of 300 girls from Nigeria (Lagos); in this sample no white children were included. Ellis gives this age as 14.22 years, S. D. 1.00 with a range between 17 and 19. Burgess and Burgess (1964) in their semi-longitudinal study of 168 girls of Bantu-speaking Baganda tribe in Uganda shows the menarcheal age as 13.40 ± 0.165 years. The school girls (N = 1002) of Alexandria near Johansberg belonging to Bantu tribes have their menarche at the mean age of 14.89 years, as reported by Oettle and Higginson (1961). This age is somewhat higher than the other studies of Bantu girls as the authors admit, and the explanation put forward by them is that of poorer nutritional and socio-economic status of this sample which is also proved by probit analysis. In another study by Burrell *et al* (1961) covering a vast amount of data (N = 47420) from Bantu school girls of Transkei Reserve in South Africa, the age at menarche is found to be 15.42 ± 0.04 years for the poor group and 15.02 ± 0.03 years for the not-poor group. The African girls, as it appears from the several studies cited above, have their puberty later than the Bengalee girls but difference is not much except in the last two samples mentioned. It may be noted that similar differences are observed amongst the Indian samples also.

The European girls (N = 2233), born and living in South Africa, were interrogated by Van Castricum (1946) on their menarcheal age. These girls give the average age at menarche as 14.65 ± 0.04 years, S. D. 1.79 years, the range being 9 to 21 years. This mean age of the white girls is not dissimilar to that of the Negro girls of Africa (South) as may be noted in the above-mentioned studies. It is, however, higher than that of the Bengalee girls of the present series.

Reports on menarcheal age from other parts of the tropical zone of the world are also available. Panama Negroes and Richmond Negroes of Virginia, as reported by Mills and Ogle (1936), give the menarcheal age as follows :

Panama	Unmarried	72	14.04 ± 0.09
Negroes	Married	56	14.05 ± 0.14
Richmond	Unmarried	56	13.46 ± 0.09
Virginia Negroes	Married	52	13.75 ± 0.17

Both these batches show the mean age to be higher than that of the Bengalees. Steggarda (1941) gives the figure of 12.91 as the menarcheal age of 42 Yucatan girls, which comes very close to the figure for the present Bengalee girls.

From the temperate zones of the world, especially from the White population, plenty of data on menarcheal age is available. Comparison with some of these may be attempted. Of these

studies from the temperate zone, Japan has already been dealt with. Kinsey *et al* (1953) gives the mean age at menarche of 5770 girls of North, Northeast and Northwest America as 13.1 ± 1.2, the range being 9 to 18 years. Gould and Gould (1932) give this age for 1037 girls from Louisiana as 13.74 ± 0.03 years, range 9 to 19 years. Nicolson and Hanley (1953) reports 12.8 ± 1.1 years as the mean menarcheal age of 91 women from Berkeley, California ; and another set of data (Waddy, 1846) on 200 girls from Cleveland, Ohio gives this age as 12.6 ± 1.1 years. The last two averages come closest to that for the Bengalee girls. All other studies from U.S.A. like those of Shuttleworth (1937), Lintz and Markow (1923), Abernethy (1925), Engle and Shelesnyak (1934), Boas (1932) show the mean menarcheal age ranging between 13.0 years to 13.74 years as do Kinsey *et al* (1953) or Gould and Gould (1932). Therefore, on the whole, the White American girls come to puberty about 6 months to 1 year later than the Bengalee girls.

Waddy (1846) found the average age at menarche of 623 English women of the working class as 14.2 years. Wilson and Sutherland (1950) worked out this age for the girls of Southern England numbering 2590 as 13.49 ± 1.91 years ; for 202 Sussex women as 13.11 ± 0.07 years ; and for 87 Yorkshire women 13.8± 0.14 years. All these mean ages of puberty for the British women are higher by nearly a year than that of Bengalee girls. But the Scotch women show a still higher menarcheal age, i.e., 15.03 ± 1.70 years (N = 10219) as reported by Kennedy (1933).

Kralj-Cereck (1956) gives the mean menarcheal age of 223 school girls of northeastern region of Slovenia, Yugoslavia as 13.61 ± 0.83 years. Skerlj (1950) gives this age for 1709 Yugoslav girls as 13.41 ± 0.02 years. These two samples are not too far away from the Bengalee sample in respect of menarcheal age.

As reported by Jacobson (1954), 288 Norwegian girls show the mean age at menarche as 14.2 ± 0.1 years. Lenner (1941) reports this age for 2000 Swedish girls as 14.48 ± 0.03 years. Scandinavian girls, therefore, have their menarche about 1½ to 2 years later than the Bengalees. The Eskimo race have their mean menarcheal age as 14.42 years with S. D. 1.20 years (N=122) as reported by Levine (1953) which is nearly 2 years more than that of the Bengalees.

Summary

In summing up, certain features are noticed :

1 The mean menarcheal age of the girls all over the world lies, generally speaking, between 12.5 and 14.5 years, but there are a few exceptions like the Bantus or the Cambodians.
2 The Japanese girls come closest to the Bengalees in the mean menarcheal age.
3 Amongst the Indians the Assamese girls come closest to the Bengalees.
4 There is no clear indication that the mean age at menarche in the Bengalees has changed within the last 100 years.

STATURE

The attainment of adult stature does not occur through a steady rate of growth from babyhood to adulthood. The velocity of growth in babies is slow but steady till the age of 6 to 8 years when a rapid increase is noticed. This spurt is known as the juvenile spurt. Then the increase in stature again continues at a slow pace interrupted by a very rapid period of growth before puberty sets in. It is known as the adolescent spurt. At the end of this spurt growth continues at a slower rate till the adult stage or full maturity is attained. In the present sample of Bengalee girls, whose lowest age is 8.5 years the juvenile spurt is already completed. The period of adolescent spurt is included in the span of age covered in this study. The last age group, as mentioned before, covers the ages between 21 and 27. It may be expected that the adulthood is attained by these girls in the last age group. However, as no official or unofficial record of adult stature of Bengalee girls is available, it cannot be emphatically claimed that the stature of the last group is the final one. The number of girls in this group is also small ; so unless and until more data are collected from the girls of above 20 years of age, the adult stature cannot be estimated.

Table VII : Statistical constants for stature of Bengalee girls according to age

Age in years mid-point	Total number	Mean (in centimeter)	S. E.	S. D.	Increments
9	34	133.10	.86	5.00	—
10	193	136.33	.45	6.25	3.23
11	198	142.53	.51	7.20	6.20
12	181	146.00	.49	6.55	3.47
13	199	150.19	.40	5.65	4.19
14	215	151.88	.37	5.46	1.69
15	215	152.65	.38	5.55	.77
16	290	152.85	.33	5.70	.20
17	236	152.91	.34	5.20	.06
18	263	153.15	.36	5.95	.24
19	226	153.35	.36	5.50	.20
20	163	153.95	.36	5.45	.60
20+	123	154.65	.50	5.55	.70

Growth curve

The height vertex representing the stature of 2536 girls was measured. The means of stature for girls in each age group together with their standard errors and standard deviations are given in Table VII. The means are plotted against age in Figure 2. This distribution of the means assumes the familiar curve for growth.

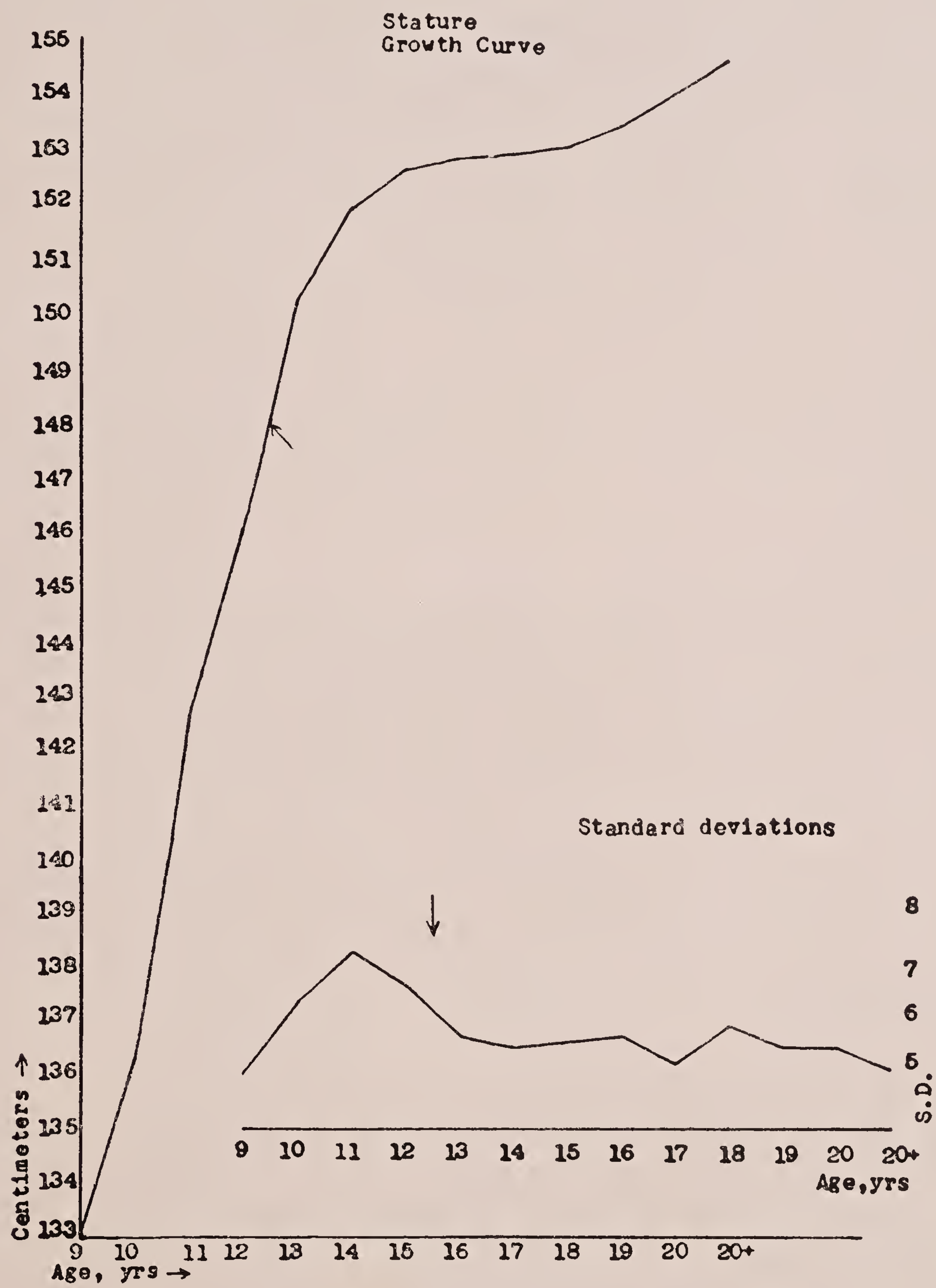


Fig. 2. Growth curve and distribution of +1 S.D. for stature. Arrows point to mean menarcheal age.

Velocity curve

The differences between mean values in succeeding age groups are plotted against age in Figure 3. It will be seen from this figure that there is a marked rise of 6.20 cm in stature

between ages 10 and 11 years while the rise in the preceding age, i.e., from 9 to 10 years, is 3.23 cm. Between 11 and 12 years of age the stature has increased by 3.47 cm. and between 12 and 13 it is 4.19 cm. Thereafter the velocity of growth has diminished till the girls have reached their 17th year. It may be also noticed that the growth in stature has not come to a stop at 17 years of age but continues at a very slow rate till the terminal age group (20+ years) of this sample.

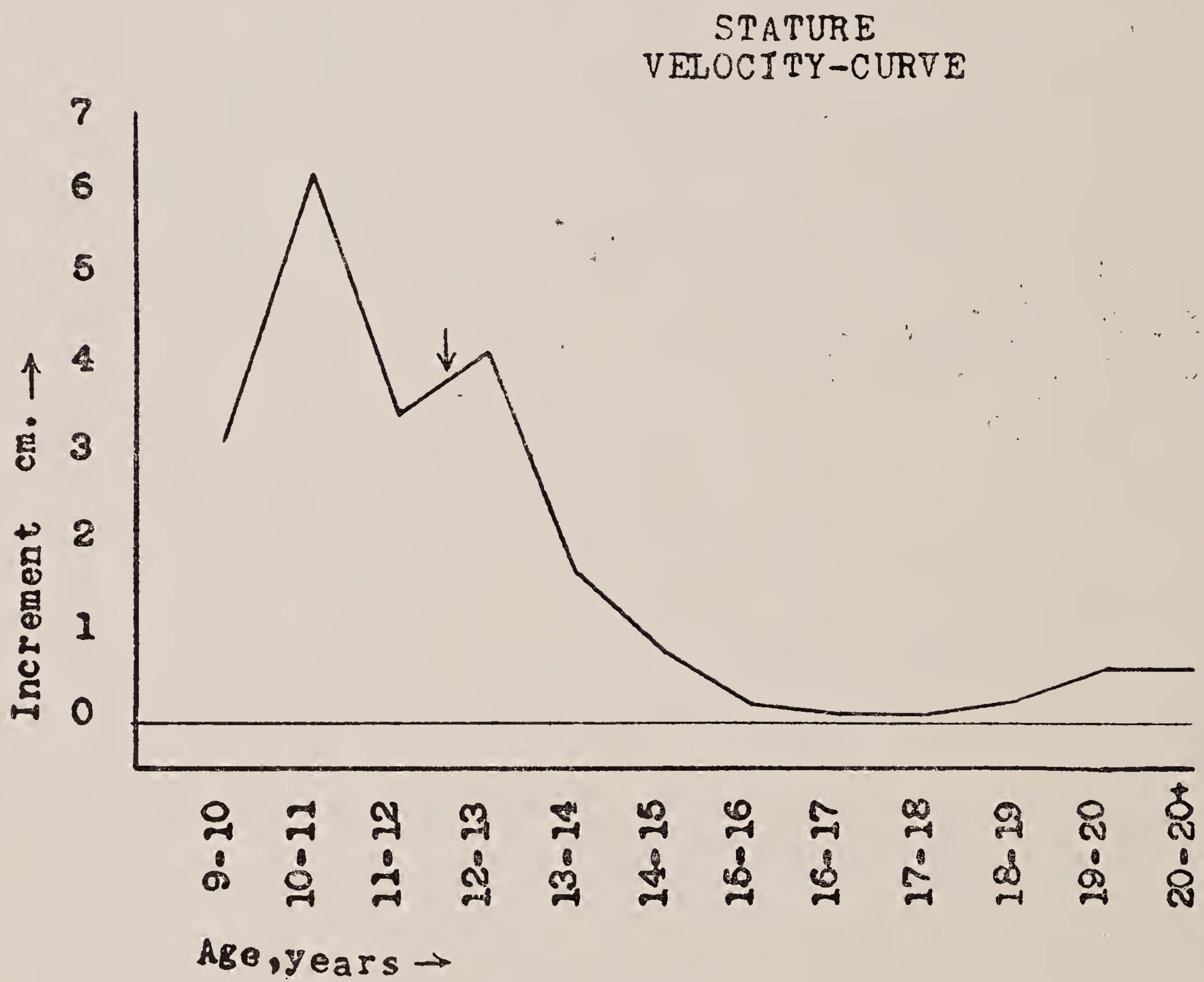


Fig. 3. Velocity curve for stature. Arrow points to mean menarcheal age.

Standard deviation

Plus one standard deviation for means in each age group has been plotted in Figure 2. The curve for the distribution of these standard deviations shows a steady and steep rise from 9 through 11 years of age after which the line comes downwards at the same pace as in its upward journey. From 13 years of age the line runs horizontally, except for a little fall at 17 and 20+ years of age.

Age at menarche and growth spurt

The almost universal phenomenon of sudden rise in stature during adolescence is noticed in both boys and girls. In the present sample this sudden shooting up of stature occurs before the mean age at menarche for the entire sample, which is found to be 12.48 years with a stan-

dard deviation of 1.27 years. This mean age at menarche has been indicated with arrows in figures 2 and 3 against the growth curve, standard deviation and velocity curves. The spurt or the highest increase (of 6.20 cm.) from one age group to another for stature in the present sample takes place between 10 and 11 years of age, and it is premenarcheal in physiological time.

But the maximum difference alone between succeeding age groups is not sufficient to show the spurt. The scatter or variation of the individual values can be judged by the standard deviation of mean for any age group. The greater the scatter the higher is the value for the standard deviation, and the scatter is greater when the stature or any other dimension in a homogeneous population shows a sudden increase. Based on this reasoning, the stature for the present sample of Bengalee girls shows the spurt at 11 years of age, i.e., one and a half years before menarche.

Comparison with other studies

The present sample has been compared with several similar samples taken from published literature. Since no data are available on Indian girls the comparative materials come from places outside India.

A large number of studies have been conducted on the growth of the American girls. Some of them are included here for comparison, Boas (1932) published cross-sectional growth data from the American Jewish and non-Jewish girls from the Horace Mann School, New York. The data comprised the age group 6 through 20 years, and the total number measured was 116 Jewish and 236 non-Jewish girls. The Brush Foundation study, conducted by Simmons (1944), dealt with White girls of America aged between 9 through 18 years. This was a longitudinal study but the means were also provided in cross-sectional form. The girls numbered 484 and were above average in economic status. The third study, that has been used, is on the American girls taken at the Fels Research Institute. This was also a longitudinal one but had been expressed cross-sectionally as well. It covered the age groups from birth to 18 years. The other studies from America, included here, do not cover a wide range of age as the former ones but include the higher age groups. Barker and Stone (1936a & b) studied Stanford University girls semi-longitudinally. They measured altogether 1290 girls of which 1134 were measured after one year and 446 after a two-year interval. The age range of the subjects was between 17 and 21 years. Donalson and his colleagues (1943) published results of their study on 209 girls aged between 17 and 20 years from different colleges of Iowa, Kansas, Minnesota, Ohio and Oklahoma. This was a longitudinal study, each girl being measured once every year for four years. The results were, however, given cross-sectionally. Finally Gould's paper (1939) on a longitudinal study of girls of the Newcomb College for Women in New Orleans may be mentioned. The sample consisted of 1505 girls from 16 to 22 years of age and were measured repeatedly from their entrance to the college to the end of their terms.

All the above-mentioned materials come from Americans of European origin. The only data from Europe are those from the British girls (Welsh and English), published by Fleming (1933), which dealt with girls upto 19 years of age.

Data based on subjects of non-European origin are few and far between. However, some have been included in the comparison. First come the data on two sets of Japanese girls, one of those who were born in Japan aged 6.5 through 19.5 years (from official Japanese data) and the other (N = 433) of those born in America (age limits were 5 years and 18 years). The author compared (Greulich 1957) these two sets with a purely American series from the Brush Foundation. The same author (1951) is further responsible for working on a sample of 846 girls from Guam, an island of the Polynesian group in the Pacific Ocean. The ages of the girls range from 6 through 17 years. Another set of data from non-European race comes from Africa, on the school girls of the Baganda tribe in East Africa, studied by Burgess and Burgess (1964). This is a mixed longitudinal study on 364 girls between ages 6.7 to 18.4 years. Tanner and O'Keeffe (1962) published a set of data on age at menarche, stature and weight on 336 Ibo girls from Nigeria. The age range of the Ibo girls in this study was from 12.5 to 19.5 years. The Kwangtung Chinese school girls were studied for their physical growth by Appleton (1928). These Chinese girls were residing in Hawaii. They belonged to the age groups 6 to 20 years, their total number being 354. The last set of data comes from a mixed population but predominantly European who were residents of Guatemalan cities and belonged to the higher economic status; their ages ranged from 7 through 17 years, the total number being 230. These mixed European girls have been compared with the Mayan girls from lower socio-economic status in the same paper by Sabharwal *et al* (1966). But only the data on the mixed group have been compared with the present sample.

Of the studies mentioned above, the growth curve and velocity curve of some have been plotted. One study from each region representing different racial groups has been selected for the plotting. The main reason for this selection is to avoid an overcrowded and clumsy picture.

The study on Hebrew and Non-Hebrew girls by Boas (1932), when compared with the present series, shows that both the Horace Mann groups are shorter than the Bengalee girls at the age of 9, nearly equal at 10 and 11, but after 11 years of age both the former groups of girls shoot up in height to exceed the Bengalees and finally at the age of 20 the Hebrew girls are 8 cm. and the Non-Hebrews 10 cm. taller. The age of the maximum rate of growth of the Hebrews is 12.1 ± 1.2 years and of the Non-Hebrews 12.0 ± 1.2 years. Compared to them both, the Bengalees are precocious by one year. This age of maximum rate of growth in the Horace Mann sets coincides with the highest value for standard deviation which also occurs a year later than in the Bengalees. The mean menarcheal age for the Horace Mann Series is 13.1 ± 1.2 year which is a little more than 7 months than that for the Bengalee sample. The Horace Mann and the Bengalee series uniformly show the spurt in stature about a year previous to their respective ages at menarche.

The Brush Foundation Series (Cleveland, Ohio) is the only study which, compared with the Bengalees, shows higher stature than the latter at the age of 9 years. All through the age groups from 9 to 17 the girls in the Brush Foundation study are taller than the girls in the present sample. But in both the series the highest increase occurs between the ages at 10 and 11 years. After 13 both show less and less increase in stature as the age advances. Ultimately at the age of 17 years the Brush Foundation girls are 12.4 cm. taller while at 9 they were only 1.9 cm. taller. This difference is mainly due to the higher rate of increase in the former girls than in the Bengalees. Their higher economic status may also be responsible for this higher stature.

The third study comes from Fels Research Institute (Yellow Springs, Ohio), called the Fels normative data for girls. In this series the acceleration of growth from 9 to 12 years of age is marked, from 13 to 14 the velocity is lessened and thereafter growth is very slow up to 18 years. Unfortunately nothing can be known about the growth of these girls beyond the age of 18 years. The semi-longitudinal study on Stanford girls by Barker and Stone (1936) when compared with the present study shows that between the ages 17 and 21 the Stanford girls do not show any increase in stature but the Bengalee girls continue to grow, though slowly, up to the age beyond 20 years. But the authors in Fels study say that the girls who were measured repeatedly between 17 and 20 years did increase in height and this increase was small but significant. The total increase from 17 to 20 years in Fels girls is 0.4 inch i.e., about a centimeter which is very similar to the increase (1.02 cm.) in Bengalee girls for the corresponding age groups.

The data on the college girls of U.S.A. studied by Donelson *et al* (1943) show increments of 1.2, 0.4, 0.4 and 0.5 cm. totalling 2.50 cm. for the age group 17 through 20 years and the authors state that this increase is significant. The figures for increments for the corresponding age groups in Bengalee girls are .08, .12, .30, ,60 cm. which give a total of 1.10 cm. The study of Donelson *et al* therefore shows a greater increase in height up to 20 years of age than that in the present study for the same period.

Gould's paper (1939) on the growth of the girls of Newcomb College shows definite increase in stature in every age group from 16 years through 22 years of age. Even the 19 year group showed increment beyond their age of 22 years. Gould concludes 'that shorter students, regardless of age, grow slightly more in college than taller students'. Carter's work (1932) on the Old American College women also shows increase in stature beyond the age of 20 years. The data consist of various racial strains from Europe, mainly British. These 154 Old American College women belonged to the ages 16 to 25 years. The present study also corroborates Gould's and Carter's findings.

The next study in the series comes from the U.K. The Welsh and English school girls as reported by Fleming (1933), show 5.3 cm. less value for stature than the Bengalees at the age of 9 years. But throughout the period from 9 to 18 years of age the British girls increase in stature much more rapidly than the Bengalee girls, and the ultimate stature of the former

at the age of 18 years is 7.6 cm. more than that of the latter. In both the samples, however, higher velocity is noticed up to the age of 13 years after which the velocity of increase slows down, though the British girls maintain higher rate than the Bengalees after 13 years of age.

The growth in stature of the two sets of Japanese girls reported by Greulich (1957) shows that the girls in both the sets are considerably shorter at the age of 9 years, but while the native Japanese girls are all along of shorter stature than the Bengalee girls, the American-born Japanese increase more rapidly and exceed the Bengalees in stature after 12 years of age; they maintain this superior position till the last age group of 18 years when they are 1.05 cm. taller. At 18 years of age the native Japanese girls are 0.45 cm. shorter than the Bengalees. In the rate of increase the American-born Japanese resemble the Bengalees in the general pattern, i.e., after 13 years of age the velocity diminishes, while in the case of the native Japanese this diminishing velocity is noticed from 12.5 years or 6 months earlier. But the spurt denoted by standard deviation in the native Japanese girls takes place a little later (about 6 months) than that in the Bengalees.

Greulich's study (1957) on the physical growth of Guam girls show a markedly short stature compared to the Bengalees at the age of 9 years. The difference between the means of their stature for this age group is 12.2 cm. At this age Guam girls are the shortest among all the samples considered here and are shorter than the Bengalees for every age group. While the Japanese girls at the age of 16.5 years come very close to the Bengalees, the Guam girls are more than 2 cm. shorter at this age. But the growth patterns of the Bengalee and the Guam girls show much similarity. In the velocity also the Guams show less increase after 13 years of age as do the Bengalees.

The Kwangtung Chinese girls are also much shorter than the Bengalees at the age of 9 years, the difference in stature between these two sets at this age being 8.63 cm. The growth of these Chinese girls is more pronounced from 9 to 13 years of age. The pattern of growth between 13 and 15 years of age resembles the one for the Bengalees in corresponding ages. The Chinese girls also share the general pattern of increase in stature with the Bengalees which consists of a rapid increase between 10 and 11, a high rate of increase up to 13 years of age and a sharp decrease in the velocity subsequently.

The stature of the Baganda girls studied by Burgess and Burgess (1964) has been reported in age groups the midpoints of which fall .6 or .5 years later than in the Bengalees for every corresponding age. Up to the age of 11.5 years the Baganda girls remain shorter but they go ahead of the Bengalees from this age onwards to a marked degree. Finally, at about 18 years of age, the Baganda girls are nearly 4 cm. taller than the Bengalees of the same age. The velocity of growth for these two samples depicts some differences in early age groups from 10.5 to 11.4 years, the Bagandas showing less increment. But they increase faster in the next age group than the Bengalees. This means that the marked increase in the former occurs a year later than among the Bengalees. The mean menarcheal age in the Baganda series is 13.40 ± 0.165 years which is

a year more than that in the Bengalee. The difference in the age of maximum growth in the two series may thus be associated with the difference in their mean menarcheal ages. However, in both the cases the maximum velocity is difinitely premenarcheal, being about a year and a half before the mean age at menarche for the Bengalees and nearly two years before in the Bagandas. The standard deviations also corroborate this fact.

The second set of data from Africa are on the Ibo girls of Nigeria reported by Tanner and O'Keeffe (1962). The age groups in this sample are also ahead of the corresponding age groups in the Bengalees by 0.5 or 0.4 years. The Ibo girls, unlike the Bagandas, are shorter than the Bengalees at 12.5 years ; but in the next age group the Ibos exceed the stature of both the Bagandas and the Bengalees. After 13.5 years of age the Ibos show an irregular rate of growth. This irregularity is, however, less than it is in the Chinese. The Ibo girls at 19.5 years are nearly 6.5 cm. taller than the Bengalee girls. In both the Ibos and the Bengalees the girls show increase in stature after 18 years of age and it is more pronounced in the former.

The last group selected is the Guatemalan studied by Sabharwal *et al* (1966). Like all the other samples discussed so far, the Guatemalan sample also shows shorter stature at 9 years of age than the Bengalees but after 10.5 years of age the Guatemalans show higher stature throughout the rest of the period up to the age of 17 years. At this age. they are 6 cm. taller than the Bengalees. The rate of increase in the Guatemalan girls is much more than that in the Bengalees between 11 and 12 years of age. The rate slows down from 12, while in the Bengalees the process begins a year later.

Summary

In summing up the foregoing comparisons some salient features may be mentioned :

1 the Bengalee girls are taller at the age of 9 years than all the girls in the abovementioned samples except in the Brush Foundation study.

2 they are shorter at 18 years of age than all of them, excepting the Japanese, the Chinese and the Guam girls.

3 The rate of increase on the whole is less in the Bengalees than in others.

4 The premenarcheal acceleration in stature takes place about a year and a half before the age at menarche which is within the normal time limit, as stated by Tanner (1962).

5 The rate of increase diminishes after 13 years of age, and this finding is shared by almost all the groups.

6 The increase after 18 years of age as noticed in the Bengalee girls, is also common in Newcomb College women, women in the study of Donelson *et al.*, Horace Mann Non-Hebrew school girls, and the Ibo girls.

WEIGHT

Weight has been an essential measurement in growth studies. It gives the idea of the sum total of growth in all dimensions including bones, muscles, fat and internal organs.

Ordinary portable spring balance was used for recording the weight of the girls in the present sample. Heavy garments like woollen sweaters and tunics, and shoes were removed before the subjects were weighed. The scale was checked from time to time for accuracy. The weight was recorded in kilograms and grams.

Though the mean, standard deviation and the standard error of the mean for this measurement of the present sample had been worked out, it was realised that the frequency distribution of weight within any age group was mostly skewed and the above-mentioned statistical constants were not enough to ascertain the true central tendency of the dimension. Accordingly, each reading for weight was converted into logarithmic units and statistical constants were arrived at on the basis of these transforms. Since, however, most comparable materials on weight are reported on readings without transformation, comparisons of the present sample with those materials are also based on direct readings. The statistical constants of the direct readings of weight are shown in Table VIII, growth curve in Figure 6 and velocity curve in Figure 7.

Table VIII : Statistical constants for weight of the Bengalee girls according to age

Age in years mid-point	Total number	Mean in kg.	S. E.	S. D.	Increment
9	34	26.45	.94	5.5	—
10	193	27.35	.36	5.03	0.90
11	198	32.45	.44	6.35	5.10
12	181	34.60	.46	6.25	2.15
13	199	39.65	.45	6.40	5.05
14	215	40.85	.42	6.30	1.20
15	215	42.60	.50	7.40	1.75
16	290	43.50	.43	7.25	0.90
17	236	43.65	.47	7.25	0.15
18	263	43.55	.41	6.60	—0.10
19	226	43.85	.48	7.15	0.30
20	163	43.75	.50	6.40	—0.10
20+	123	46.98	.75	8.30	3.23

Table IX : Statistical constants for log weight of the Bengalee girls according to age

Age in years mid-point	Total number	Mean	S. E.	S. D.	Increments
9	34	1.418	.0125	.0730	—
10	193	1.432	.00565	.0775	.014
11	198	1.502	.00654	.0920	.070
12	181	1.530	.0060	.0805	.028
13	199	1.581	.0052	.0735	.051
14	215	1.605	.0040	.0570	.024
15	215	1.622	.0049	.0715	.017
16	290	1.630	.0038	.0650	.008
17	236	1.636	.0041	.0635	.006
18	263	1.636	.0041	.0665	.000
19	226	1.637	.0092	.0590	.001
20	163	1.642	.0047	.0595	.005
20+	123	1.665	.0069	.0770	.023

The growth curve

The statistical constants of the log transforms are given in Table IX. Figure 4 shows the distribution of the means plotted against the respective age groups. The curve shows steep rise between 10 and 11 preceded and followed by smaller rises between 9 and 10 and between 11 and 12 years of age respectively. From 12 to 13 the line again rises sharply and changes its direction and runs semihorizontally till the age of 17 years. From 17 to 20 years the curve runs parallel to the base line. After 20 years it again shows an upward movement. On the whole, this curve looks similar to the general growth curves.

Velocity curve

The differences of means of the log transforms of weight are plotted against the respective age-group intervals in figure 5. On the plottings of this curve are given in parenthesis the differences of the antilog values of the means of log transforms. The antilogs have been used to get the idea of the age by age increment in kilograms as log units do not indicate the absolute values.

The curve reaches its highest point in the group between 10 and 11 when the weight increases by 4.73 kg., the second highest peak falls in the period between 12 and 13 years of age when the increase is 4.23 kg. After 13 years of age there is a decline in the velocity ; at 18 the increment has nearly stopped ; between 18 and 20 it is very small. The velocity again shows some acceleration between ages 20 and 20+ years, when the weight increases by 2.39 kg.

Standard deviation

The standard deviations of means (log thansforms) of weight for each age group are shown plotted in Figure 4, below the growth curve. There is a rise from 9 to 11 years of age in standard deviation curve ; the peak lies at 11 ; then the curve comes down quickly up to 14 years age group. After this age, except for the two very small rises—one at 15 and another at 18—the curve is nearly horizontal in form. In the age group between 20 and 20+ years the standard deviation shows some rise.

Age at menarche and growth spurt

The mean age at menarche (12.48 years) for the whole series is indicated on the curves for growth, velocity and standard deviation (Figs. 4 and 5). From all these three curves it may be noted that the spurt in weight for these girls occurs nearly one and a half years earlier than the mean age at menarche. The highest increment in weight takes place within 11 years of age, the highest value for the standard deviation occurs for the 11-year age group also—showing the spurt. It may be inferred that the spurt in weight for these Bengalee girls is premenarcheal.

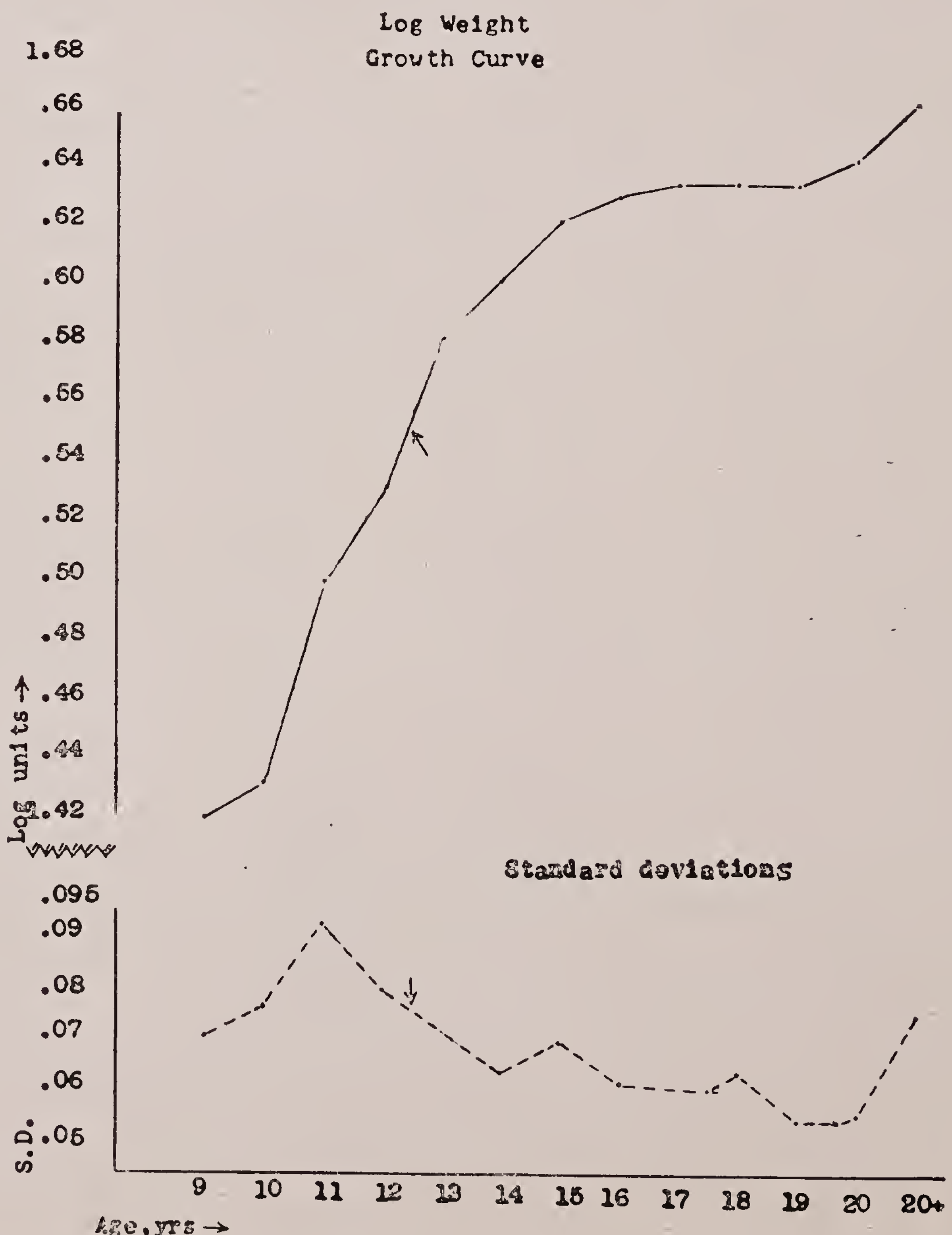


Fig. 4. Growth Curve and distribution of +1 S.D. for log weight. Arrows point to the mean menarcheal age.

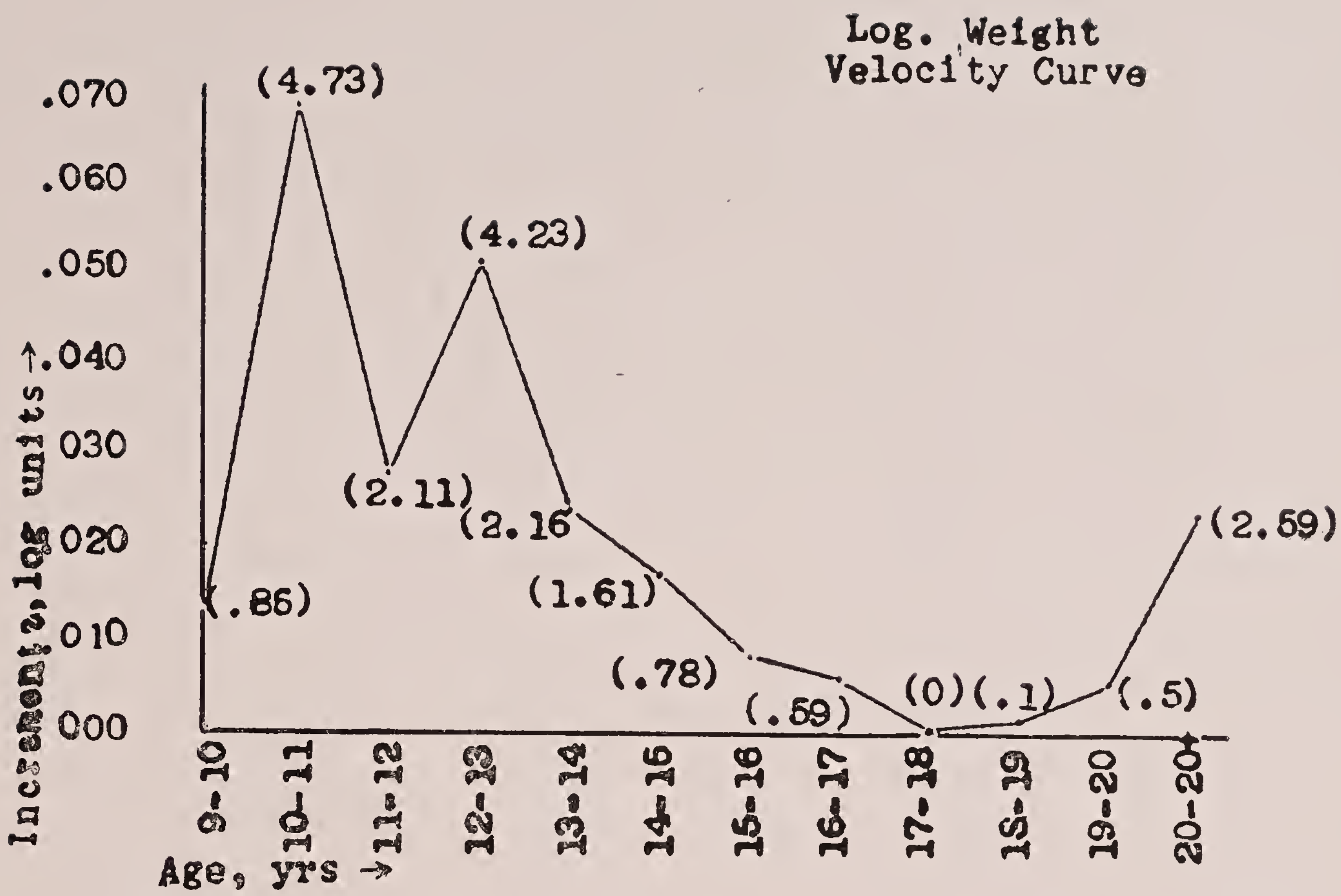


Fig. 5. Velocity Curve for log weight. Arrow points to the mean menarcheal age.

Comparison with other studies

The weight of the growing children had been recorded by a number of workers on growth problem, from almost all parts of the world. Of these studies, only a few have been picked up for comparing with the present sample.

Simmon's study on Brush Foundation Series shows that the American girls are 1.65 kg. heavier than the Bengalee girls at the age of 9 years, and as the age advance this difference increases and ultimately at the age of 18 years the American girls weigh 17.35 kg. more than the Bengalees. The American girls do not show any stability in weight up to 18 years of age. Both show highest increase between the ages 12 and 13 years. After 13 years of age the weight in the Bengalee series shows much less increment in succeeding age groups while the Brush series shows high velocity up to 15 years of age and then gradually it slows down.

The means for weight of the Guatemalan girls studied by Sabharwal *et al* (1966) show higher value at 9 than the Bengalees of that age. Like the Brush Foundation series the Gautemalan series also shows higher weight than the Bengalee all through the age groups, but at the age of 17 years—the ultimate age for Guatemalan girls in the study—they occupy an intermediate position between the Brush and the Bengalee girls. At 17 the Guatemalan girls are 8.30 kg. heavier than the Bengalees. The girls from Guatemala show their highest increment between the ages 12 and 13 years while the velocity of increase abruptly falls from 13 to 14 years of age, as is the case with the Bengalees.

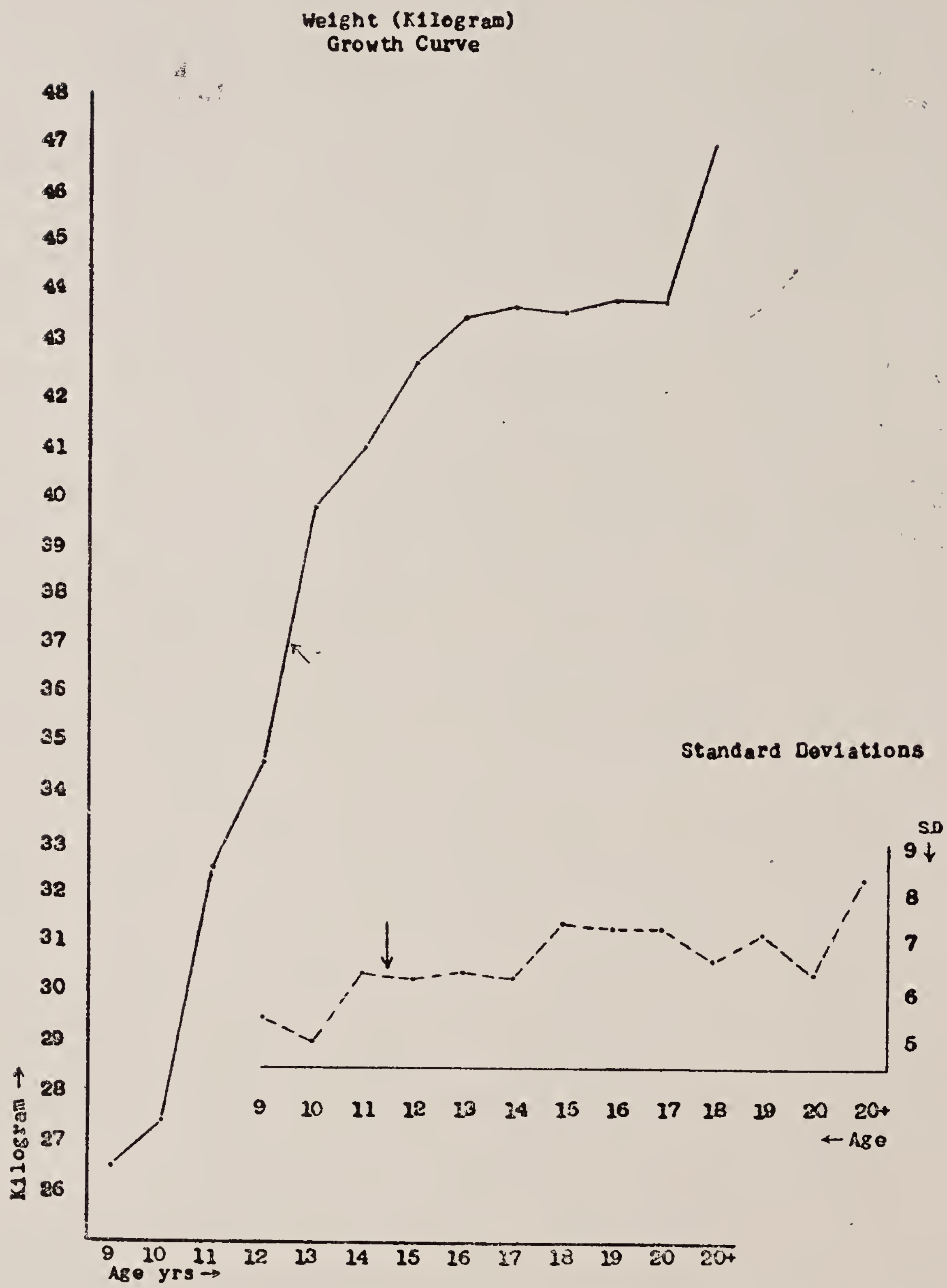


Fig. 6. Growth Curve for weight in kilogram. Arrow points to mean menarcheal age.

The Nigerian Ibo girls from 'highly privileged' class, studied by Tanner and O'Keeffe (1962) belong to the ages 12.5 to 19.5 years. At 12.5 these Nigerian girls weigh nearly the same as do the Bengalees but soon after they exceed the Bengalees and become heavier and heavier as the age advances. The Ibo girls show a near-stable condition in their weight from 17 years onwards as do the Bengalees. Their year-to-year increments are more than those in the corresponding ages of the Bengalees except between 15.5 and 16.5 years of age. The sharp increments in weight between the ages 12.5 and 13.5 years and again between 15.5 and 16.5 years in the Nigerian girls are both a year later than in the Bengalees. Their menarcheal age is also 1½ year later (14.07 ± 0.16 yrs.).

The Baganda girls studied by Burgess and Burgess (1964) are heavier for all age groups than the Bengalees. The Baganda girls show that they increase in weight steadily between 9 and 13

years of age, after 13 the increase slows down consistently up to the age of 17 years and from 17 to 18 there is hardly any increase. While the Bengalee girls do not show such uniformity in the curve but in general form—high velocity up to 13, low up to 17 years of age—both the samples resemble each other. At 18 years of age the Bagandas are nearly 11 kg. heavier than the Bengalees.

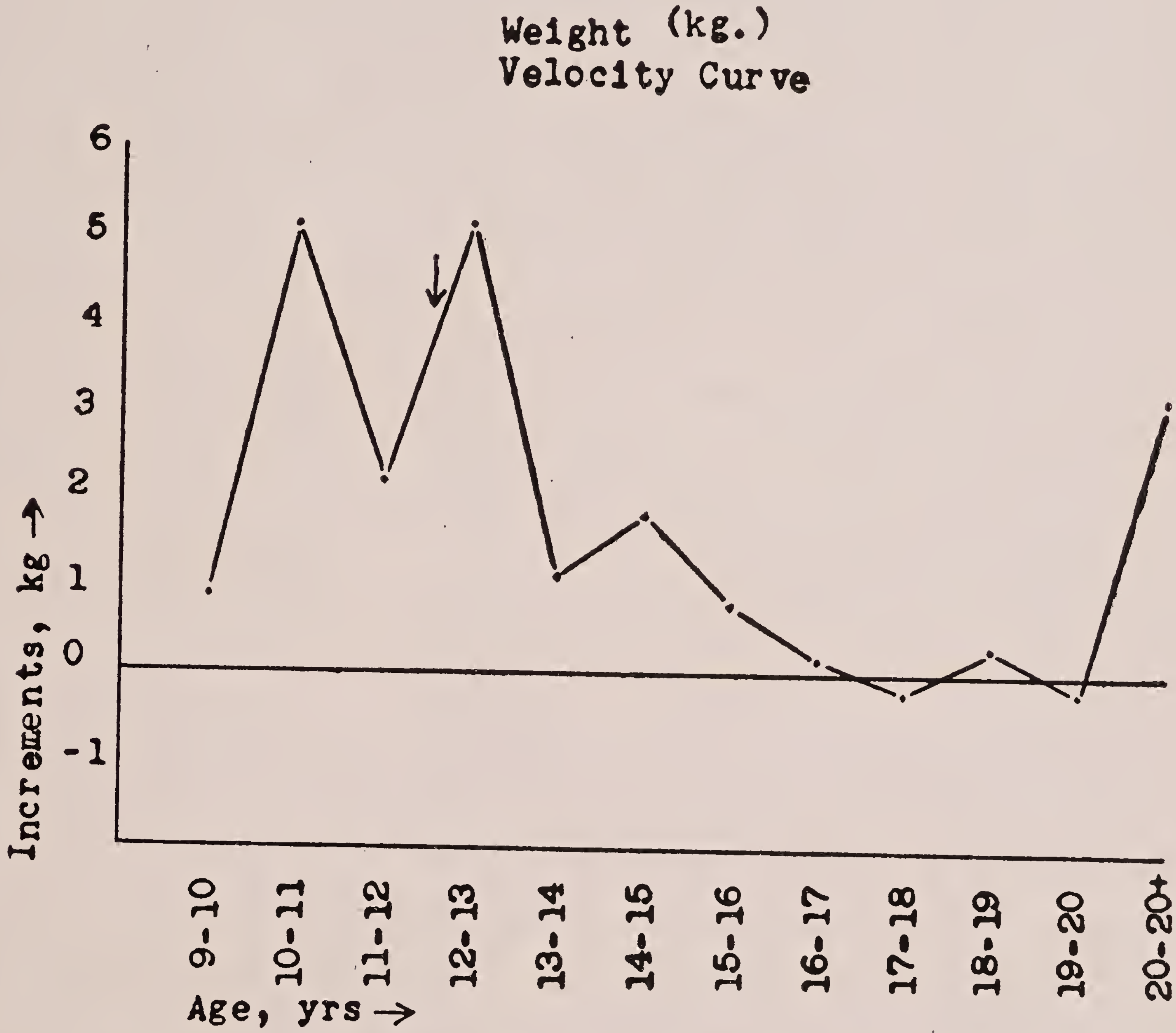


Fig. 7. Velocity Curve for weight in kilogram. Arrow points to mean menarcheal age.

The weight of the Kwantung Chinese girls living in Hawaii, and belonging to the age groups 6 through 20, reported by Appleton (1928), when compared with the present sample shows that at 9 years of age the Chinese girls are lighter by about 3 kg. than the Bengalees. The 'inferior position in weight for the Chinese girls is maintained from 9 to 13 years of age. At 14 years of age and beyond the Chinese girls exceed the Bengalees in weight. But these girls come closer to the Bengalees in weight in their late teens. The Chinese girls do not show any distinct peak velocity in the early teen ages as do the Bengalees. The gain in weight between the ages 15 and 16 and 18 and 19 years is conspicuous in the Chinese sample and is not shared by the Bengalees.

Like the Chinese girls, the Guam girls studied by Greulich (1951) also weigh much less than the Bengalee girls up to 14 years of age; After 14 the former series shows higher values (3.35 kg. more than the Bengalees) till 17, the highest age group in the series. Both the series show about the same intensity of increments till about 14 years of age.

Barker and Stone (1936) reported the weight of some University and College women in U. S. A. The mean weight of these girls shows marked annual increment from 17 to 19 years of age, the total increment for this period being 5.75 lbs. or 2.61 kg. while the total increment for the same period in the Bengalee girls amounts to 0.20 kg. only. These American girls show an abrupt increase of 4.66 lbs or 2.1 kg. between ages 20 and 21 years, while the Bengalees increase 3.80 kg. for the corresponding age. Though the values are different but the abrupt increase after 20 years of age in both the series is noteworthy.

Pryor (1936) concluded from her observation on the American girls from 9.5 to 14 years of age that gain in height is preceded by gain in weight amongst the adolescents. In the present sample the rapid gain in weight between ages 10 and 11 years goes hand in hand with the growth in stature, so no such phenomenon as weight-gain preceding height-gain is noticed in the Bengalee girls. Pryor's other conclusion, that pubescent girls gain faster (55%) during six months preceding catamenia, is confirmed by the present study, for the sharp rise between 12 and 13 years of age points to this conclusion. Sung-ken Quo (1953) observed, 'The advent of pubescence is preceded by an acceleration and followed by a retardation of growth in weight'. This finding of Sung-ken Quo is in accord with the finding in the present series.

Summary

The foregoing discussions point to the following observations :

1 The weight of the Bengalee girls shows the highest acceleration between the ages 10 and 11 years and this increment may be called spurt as is indicated by the distribution curve of standard deviations.

2 The spurt is premenarcheal in physiological time and takes place about a year and a half before menarche.

3 Six months before and after menarche the increment is rapid.

4 From 13 years of age the increment in weight slows down.

5 From 16 years of age the weight remains stationary till the age of 20 years. After 20 there is again a rise.

6 As the year-to-year increments in weight in the present sample are considerably small in comparison with the studies from other parts of the world, the Bengalee girls have relatively lighter body.

7 Except the samples from the Mongoloid races, the others show higher values of weight all through the ages from 9 to 20 years.

SITTING HEIGHT

The sitting height is one of the components of stature. Consequently the growth in sitting height affects the growth in stature.

The sitting height of the Bengalee girls in the present sample was measured by making them sit on a stool with their heads high, eyes on Frankfurt horizon, backs straight, thighs wholly resting on the stool and feet touching the ground. The statistical constants of this measurement in each age group are given in Table X. The means are plotted in Figure 8 showing the growth curve of this dimension.

Growth curve

The growth curve of the sitting height of the Bengalee girls in the present sample (Figure 8) shows an initial small rise from 9 to 10 followed by comparatively sharp rise from 10 through 13 years of age. The line bends from 13 and shows on the whole a continuous slow rise till the end. In general the curve is sigmoid in shape but short and rather flat.

Table X : Statistical constants for sitting height of the Bengalee girls according to age

Age in years mid-point	Total number	Mean (centimeter)	S. E.	S. D.	Increments
9	34	69.72	.45	2.64	—
10	193	70.53	.28	3.99	0.81
11	198	72.77	.31	4.45	2.24
12	181	74.61	.33	4.53	1.84
13	199	76.97	.24	3.48	2.36
14	215	78.17	.21	3.02	1.20
15	215	79.01	.21	3.15	0.84
16	290	78.95	.18	3.09	—0.06
17	236	79.78	.19	2.94	0.83
18	263	79.86	.19	3.09	0.08
19	226	79.64	.20	2.94	—0.22
20	163	80.02	.22	2.79	0.38
20+	123	80.84	.39	3.05	0.82

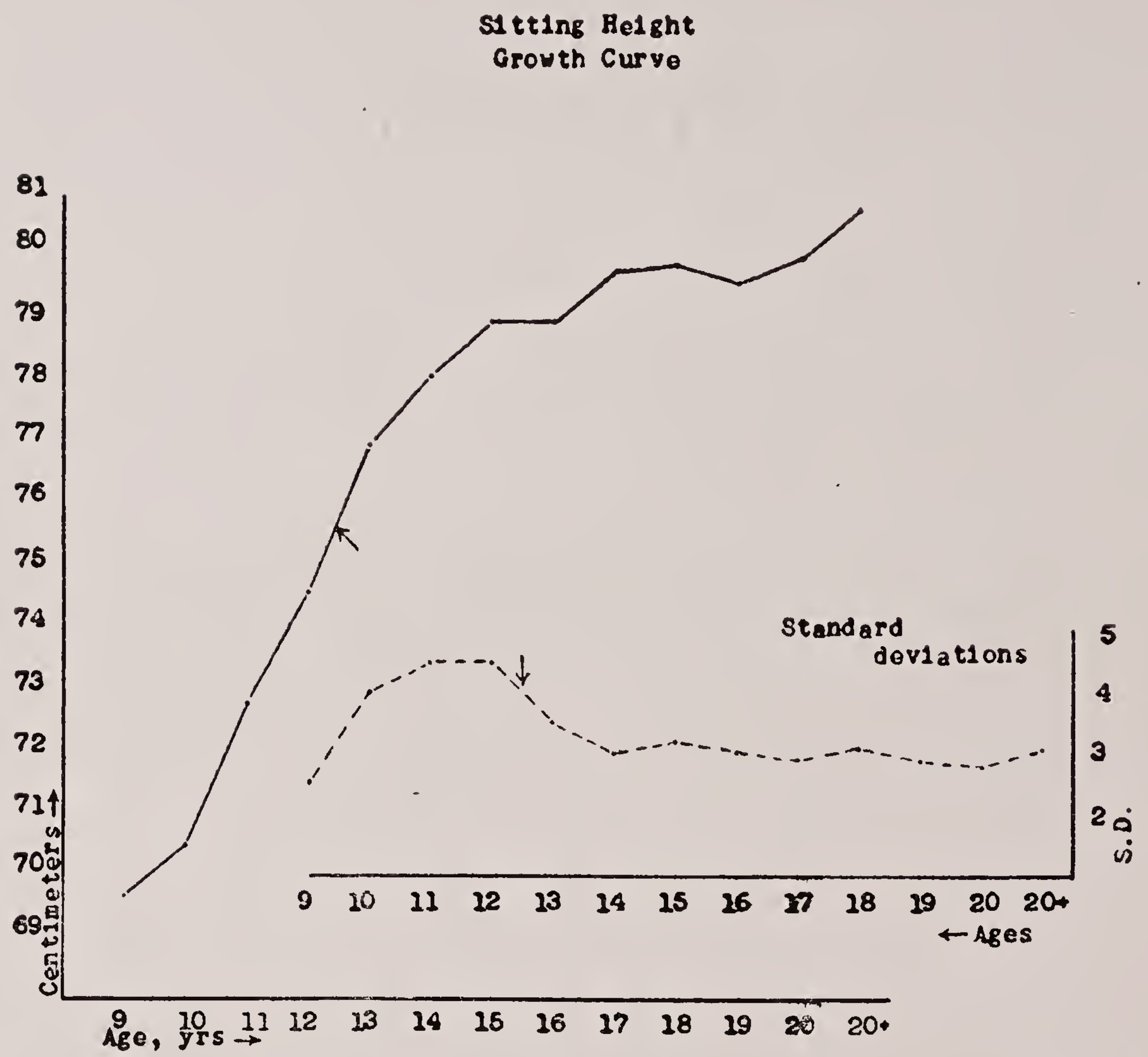


Fig. 8. Growth Curve for sitting height and the distribution of +1 S.D. Arrows point to mean menarcheal age.

Velocity curve

Figure 9 shows the velocity curve for the sitting height of the sample. It may be noticed that there are two sharp increments, one occurs between 10 and 11 years and another between 12 and 13 years of age, the increments being 2.24 cm and 2.36 cm respectively. The fall between 11 and 12 is smaller than the one after 13 years of age. From 13 years onwards the curve takes a downward course till the age of 19 years, though the fall is neither consistent nor continuous. Between the age groups 14 and 15 years the increment is small. The curve falls below zero at two points—between 16 and 17 and 18 and 19 years. These negative increments, of course, are not unexpected features in a cross-sectional study. From 19 to 20+ the curve takes an upward route.

Standard deviation

The standard deviations for the means of sitting height are potted in Figure 8 against the respective age groups. It shows a gradual rise from 9 to 11, and falls after 12 years of age. From the age 14 years onwards there are little variations in the standard deviation. The curve indicates a beginning of the spurt in this dimension from 9 years, reaching the peak at 11 and 12, and the end of the spurt by 13 years of age. The velocity curve also corroborates this feature.

Menarcheal age and growth spurt

The mean age at menarche for the entire sample is indicated by arrows in Figures 8 and 9. The accelerations in the growth curve, standard deviation and in the velocity curves, all points to the fact that the spurt in this sample in sitting height is premenarcheal. Though the rate of increment remains high up to six months after menarche (i.e., 13 years of age), the spurt shown by standard deviation is a clear indication that it is over before the first menstruation starts.

Comparison with other studies

The sitting height of the present sample is being compared with those in the studies by Appleton (1928), Shuttleworth (1939), Simmons (1944), Greulich (1951 and 1957) and Sabharwal *et al* (1966). All the studies mentioned have already been introduced in the chapter for stature except the one by Shuttleworth. Shuttleworth is widely known for his famous longitudinal study on the growth of children at the Centre for Research in Child Health and Development of Harvard University. The data from this study are divided according to various M-G groups (age at maximum growth). The M-G eleven years group corresponds to the present sample as the latter also shows the maximum rate of growth in stature at 11 years of age. For this reason this group of Shuttleworth has been compared the present sample, the ages covered are 9 through 17 years.

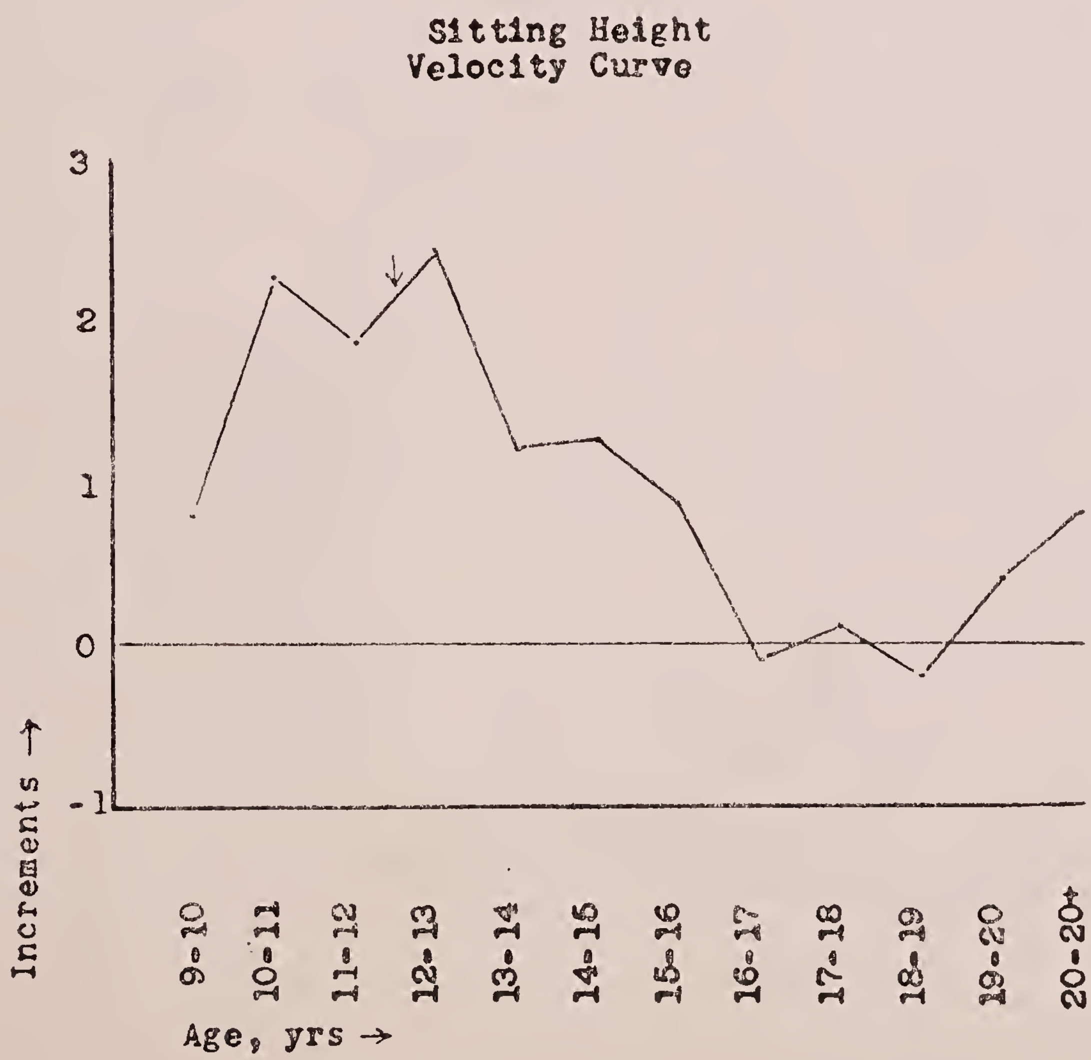


Fig. 9. Velocity Curve for sitting height. Arrow points to mean menarcheal age.

At 9 years of age the sitting height of the Brush Foundation girls is a little above 2 cm. higher than the Bengalee girls and at 17 it is a little above 8 cm. higher. The sample shows steady increment from 9 through 13 years of age after which the increase becomes less and less as the age advances from 13 to 17 years. The Bengalee girls also show the highest increment at 13 and then it falls, though the fall is not steady from one age group to another as in the case of the Brush series. The standard deviation in the Brush series is the highest at 12 which is the same as in the present series, indicating that in both the series the spurt is over within 12 years of age.

The American girls from Harvard centre have less sitting height than those from Brush. The growth curve for the Harvard series from ages 9 to 19 show, on the whole, similarity with that of the present sample. In both, the rise from 9 through 17 and the stability after 17 years of age are common. The Harvard girls are shorter by about a centimeter than the Bengalee girls at 9, but at 10 they exceed the latter and then maintain this superiority throughout the rest of the period of growth. In the ultimate age group (19 years) they attain 5.60 cm. higher value than the Bengalee girls. There is higher increment for the Harvard series compared to that for the present series for every age group. But in both, the increment is highest between 12 and 13 years of age and in both it slows down as the age advances. But even at 19 years of age the Bengalees show less increment than the Harvard girls. Between ages 17 and 19 years both the samples show markedly lower increments than in the preceding age groups. The general appearance of the velocity curve for the Bengalees is similar to the generalised pattern of annual increment line for sitting height of girls in Shuttleworth's study.

The third sample comes from Guatemala. These Guatemalan girls of predominantly European heritage have a mean sitting height higher than that of the Bengalees for every age group. At 9 the Bengalees are nearly equal to the Guatemalans but at 17 years of age the latter are nearly 5 cm. taller in sitting height than the former.

The rate of increase in them is quite high from 9 through 12 years of age, it is reduced abruptly at 13 ; it rises again at 14 and then registers a marked fall from 14 through 16 years of age. On the contrary, the Bengalees show a fall in increment after the age of 13 years.

The Guam girls studied by Greulich (1951) have a sitting height nearly 4 cm. smaller than the Bengalee girls at 9 years of age. From 9 through 13 the former series show less mean values for sitting height. From 14 to 17 years of age the Guam girls surpass the Bengalees.

The Japanese official data on the girls as produced by Greulich (1957), are shorter, as the Guams, in sitting height from 9.5 to 11.5 years of age compared to the Bengalee girls. But the former surpasses the latter thereafter and at 19.5 years of age the Japanese have greater sitting height by about 4 cm. than the Bengalees. There is a higher rate of increase in almost every age group of the Japanese series as compared to that of the Bengalees. Both the sets show acceleration in velocity after the age of 13 years, though more acutely in the Bengalees and less in the Japanese. At about the age group of 17 years both show a tendency to stabilise as the increments are very small.

The sitting height of the Kwangtung Chinese girls from Hawaii reported by Appleton (1928) shows the lowest value for 9 years-old amongst all the studies compared. It is about 4 cm. smaller than in the Bengalees. Gradually the difference between the Chinese and the Bengalees reduces and at 15 years of age the former show a higher position and retains it ; at 20 years of age the Bengalees have sitting height 2 cm. lower than the Chinese.

From 9 through 12 years of age the Chinese have a higher rate of increment than the Bengalees. The velocity in the Chinese shows a deceleration from 14, while in the Bengalees the deceleration starts a year earlier.

Steggarda (1940) reported the data on the sitting height from Negro, Navajo and White girls of age groups 20.05, 19.09 and 20.15 years respectively. The samples come from the U. S. A. The data show that the mean sitting height for the Negroes is 82.86 cm, for the Navajos 83.74, and for the Whites 86.84 cm. Compared to the girls of these three groups, Bengalee girls are much shorter in this dimension, the means for the Bengalees for 19 and 20 years of age being 79.64 and 80.02 cm. respectively.

Summary

The sitting height of the Bengalee girls discussed in the foregoing pages reveal :

1 The acceleration or the spurt in sitting height in the present study takes place before the age at menarche. The spurt is over by 12 years of age, as the standard deviation shows, though the increment is still high.

2 After 13 years of age the velocity of increment decelerates.

3 The increment is not over even after the age of 20 years.

4 Of all the studies compared with the Bengalees—except the Brush and Harvard series —the others have less mean values for sitting height than the Bengalees at 9 years of age. But ultimately all the samples exceed the Bengalees in sitting height.

5 The rate of increase from 9 through 15 years age group is the least in the Bengalee sample.

6 The spurt is earlier in the Bengalees than in the Japanese or the Americans as is indicated by the curve for the standard deviation.

THE LIMBS

Upper Limb Length

The growth of the upper limb is the sum total of the growth of several bones. The upper limb includes the humerus, radius, ulna, carpals, metacarpals and phalanges. As these bones could not be measured individually, the general growth-pattern of all these together would be taken into account in studying the length of the upper limb. This length was obtained indirectly —by subtracting dactylion height from the acromion height for each subject.

Growth curve

The statistical constants for the length of the upper limb are given in Table XI for each age group from 9 years through 20 + years. The means are plotted in Figure 10. This growth curve, though it looks like any other, is less steep. The line rises from 9 years through 13 years of age ; but after 13 the line bends towards a horizontal direction, and from 15 years to the last age group the line runs virtually parallel to the base line, with a little dent at 17 years of age.

Table XI : Statistical constants for upper limb length according to age

Age in years mid-point	Total number	Mean (centimeter)	S. E.	S. D.	Increment
9	34	57.86	.51	2.96	—
10	193	59.54	.28	3.86	1.68
11	198	62.18	.30	4.26	2.64
12	181	63.72	.25	3.38	1.53
13	199	65.60	.29	4.08	1.89
14	215	65.96	.24	3.50	0.36
15	215	66.35	.24	3.52	0.39
16	290	66.27	.20	3.38	—0.08
17	236	65.86	.22	3.38	—0.41
18	263	66.38	.21	3.40	0.52
19	226	66.38	.22	3.36	0
20	163	66.62	.24	3.06	0.24
20+	123	66.64	.29	3.20	0.02

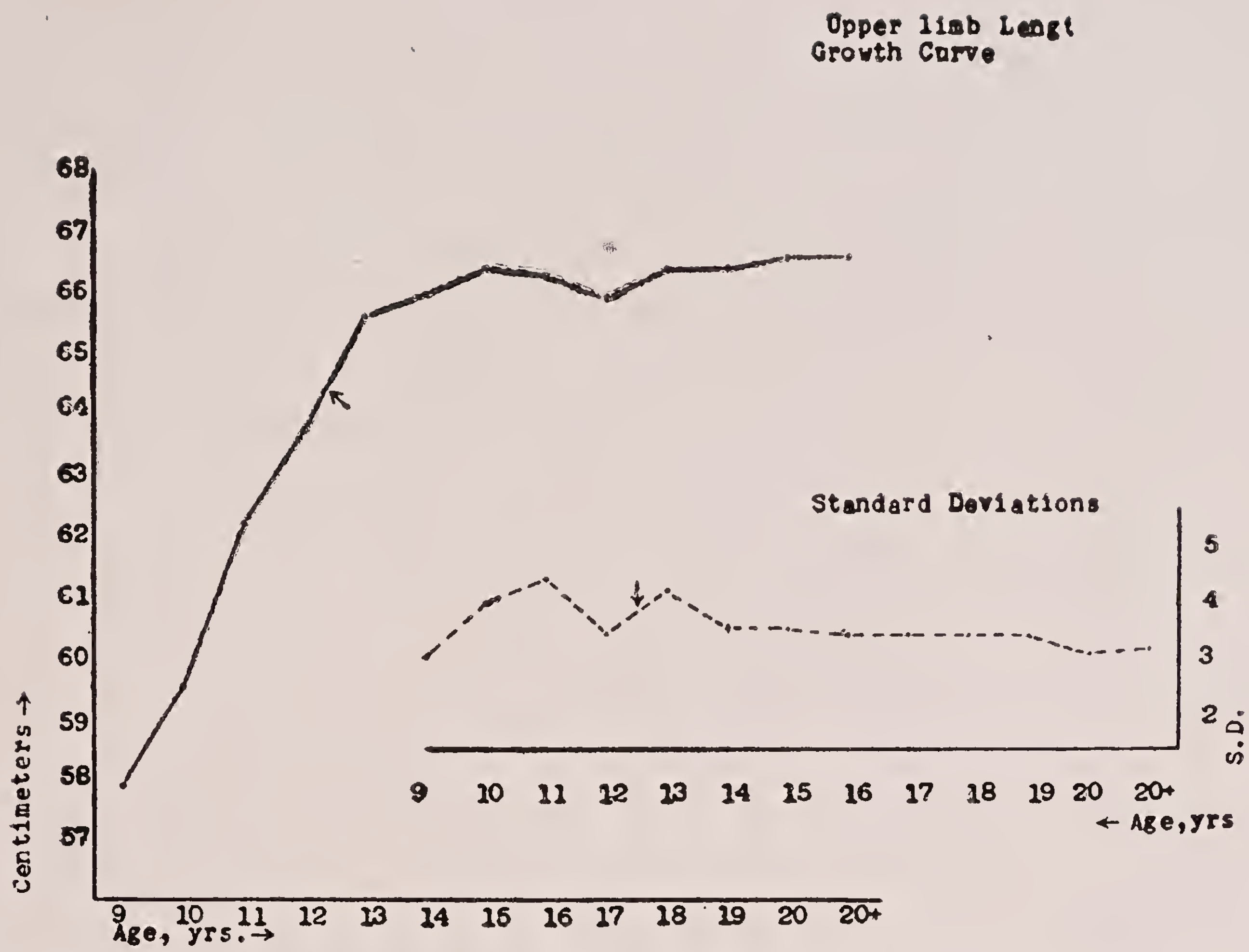


Fig. 10. Growth Curve and distribution of +1 S.D. of length of upper limb. Arrows point to the mean menarcheal age.

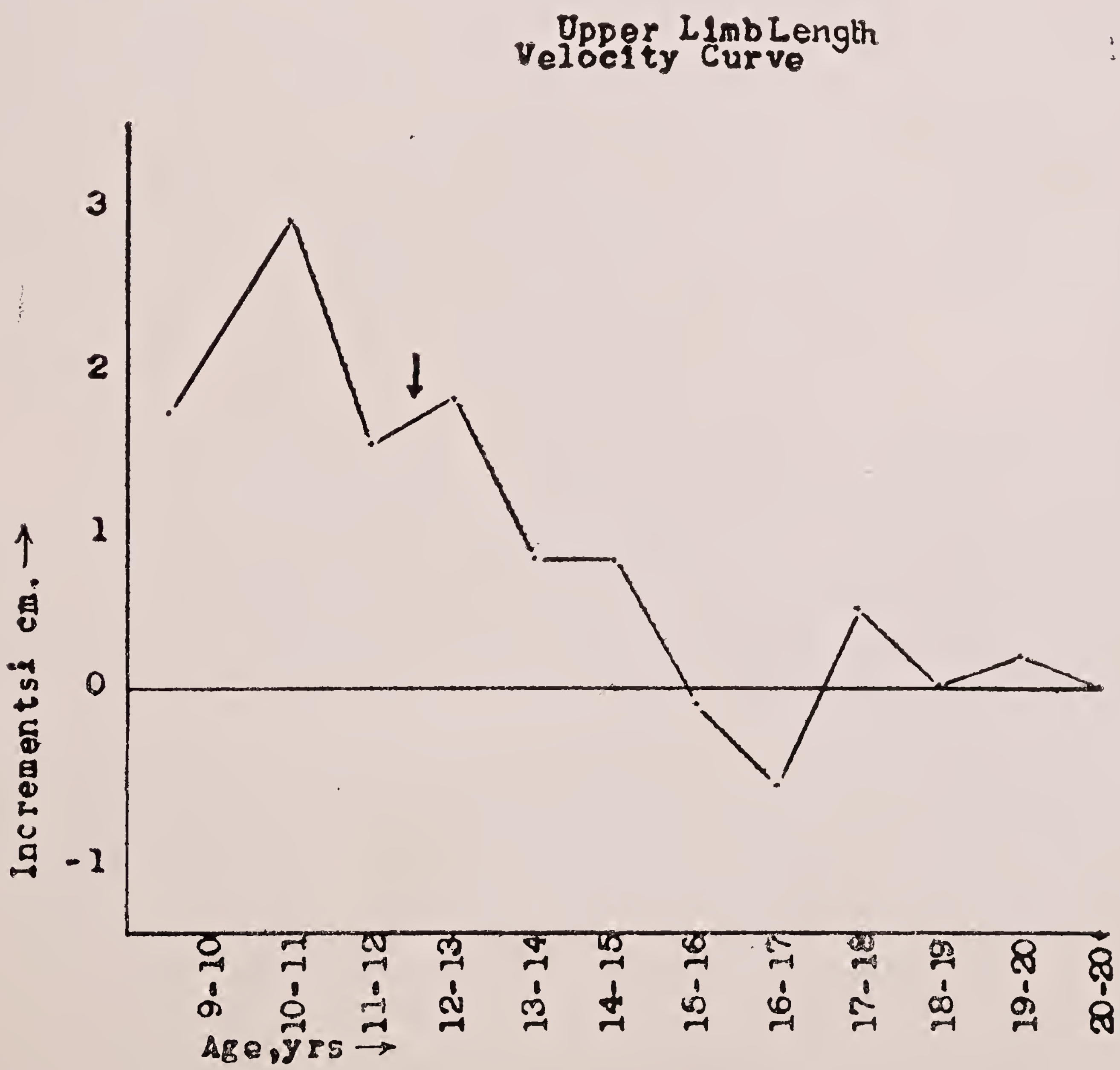


Fig. 11. Velocity Curve for length of upper limb. Arrow points to mean menarcheal age.

Velocity curve

The age-to-age increment in this dimension is given in Figure 11 and the values of these increments in Table XI. The increments in the velocity curve show a peak rise between 10 and 11 years of age, a second and comparatively small peak between 12 and 13. Between 13 and 14 years of age the velocity decreases perceptibly and continues to decrease, though in a lesser degree, upto 17 years. The curve again shows a rise of 1.6 cm between 17 and 18 years, after which it is nearly steady showing almost a stationary condition. If the lowering of the line below zero between 15 and 17 and the rise after 17 be over looked in consideration of the concession customarily given to a cross-sectional study, it may be said that from 16 years of age the upper limb does not increase in length for this sample of the Bengalee girls.

Standard deviation

The standard deviations of the means of the length of the upper limb for every age group are plotted in Figure 10. The line rises from the age of 9 years to 11 years where it reaches the highest point, it has a drop at 12 and again a rise at 13 years of age. From 14 years onwards the line runs horizontal to the base line.

Menarche and spurt

The mean age at menarche for the sample is shown by arrows on the velocity, standard deviation, and the growth curves. It shows that the spurt in this dimension takes place at 11 as the standard deviation indicates; the maximum increment, as the velocity curve shows, takes place between 10 and 11 years of age. So it may be concluded that the spurt in arm length is premenarcheal.

Comparison with other studies

Very few studies on growth have produced data for the length of the upper limb. The two studies selected for the comparison come from two distinct racial groups—one is the Brush Foundation study on White girls upto 16 years of age and the other is the study on the Chinese girls upto 20 yeors. of age living in Hawaii.

At 9 years of age the girls in the Brush sample measured about 1.6 cm less than the Bengalees in their length of the upper limb but at 16 they have nearly 3.4 cm longer arms on an average than the Bengalees. Both the series show highest rise at the age interval between 10 and 11 years after which the velocity diminishes. The marked drop in the velocity is noticed after 13 years of age in the present sample and after 14 years of age in the White sample. The standard deviations in the Brush sample do not show any perceptible rise for any age group while in the Bengalees the rise at 11 is pronounced.

The Chinese girls from Hawaii have markedly low values for the length of the upper limb than that of the Bengalees. The Chinese girls have shorter arms by 6.7 cm at the age of 9 years and at 20 years it is 2.3 cm shorter than the Bengalee girls. Both the series show higher rate of increase from 9 through 14 years of age but, the Chinese have marked irregularity in increment in this dimension from 16 to 20 years of age. The sharp drop in the velocity in the Chinese starts from 14 while in the Bengalee it starts from 13 years of age.

Summary

The length of the upper limb in the Bengalee girls indicates the following features :

1 The spurt takes place at 11 years of age. It occurs about one and a half year earlier than the age of the onset of menarche.

2 From the age of 13 years the rate of increase slows down; from 15 years of age the increment practically ceases.

3 The Bengalee girls have longer arms than the Whites and the Chinese at their early ages but the Whites in the ultimate age group of 16 years have much longer arms while the Chinese have shorter arms all through the ages as compared to the Bengalees.

4 The rate of increase in the Bengalees is generally slow compared to that of the other two groups.

5 The velocity of increase is decelerated a year earlier in the Bengalees than the Brush Foundation American girls or the Chinese girls from Hawaii.

Lower Limb Length

Like the sitting height, the length of the lower limb is a component of stature. To determine the growth rate of this dimension of the body it has been studied as a separate entity. The lower limb consists of the thigh bone or femur, bones of the foreleg or tibia and fibula and the heel bones—calcaneum and astragalus, besides the intervening cartileges, muscle and fat that go in its composition. The sitting height has been subtracted from the stature for each subject to arrive at the length of the lower limb. A portion of the hip bone also has to be included in this process. This cannot be helped, for this has been recognised by some as the nearest approach to this dimension. The inguinale would have been the correct landmark for this measurement but for obvious reason this could not be utilized.

Growth curve

The statistical constants for this measurement have been given in Table XII and the means are plotted in Figure 12 against each age group in the present sample. The line for this curve rises

Table XII : Statistical constants for lower limb length according to age

Age in years mid-point	Total number	Mean (centimeter)	S. E.	S. D.	Increments
9	34	61.62	.57	3.34	—
10	193	66.28	.36	5.02	4.66
11	198	68.81	.27	3.84	2.53
12	181	70.52	.32	4.30	1.71
13	199	72.32	.26	3.68	1.80
14	215	72.69	.23	3.38	0.37
15	215	72.54	.26	3.76	—0.15
16	290	72.84	.23	3.90	0.30
17	236	72.12	.19	2.86	—0.72
18	263	72.54	.22	3.66	0.42
19	226	72.52	.23	3.62	—0.02
20	163	72.72	.27	3.58	0.20
20+	123	72.82	.32	3.54	0.10

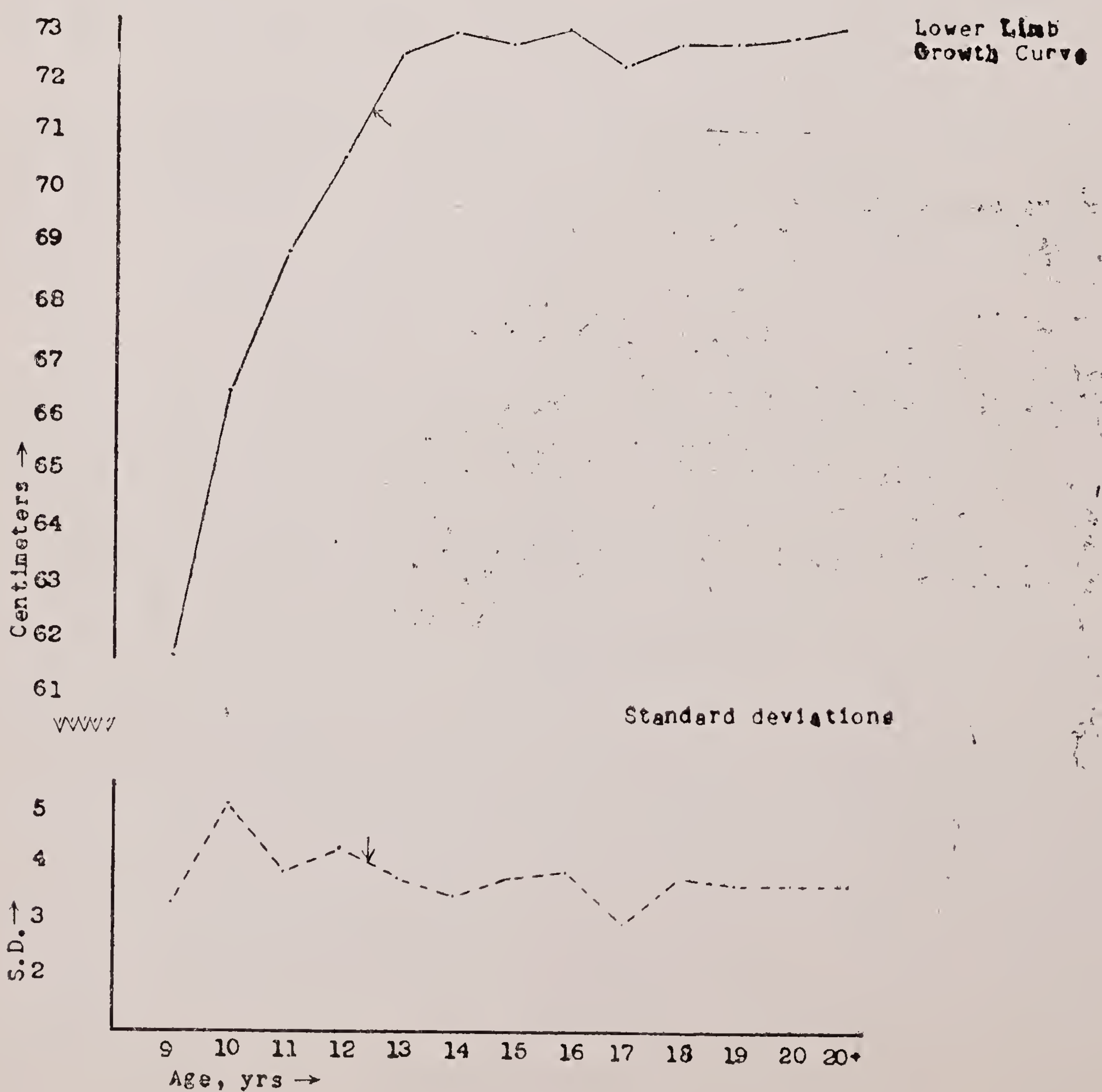


Fig. 12. Growth Curve and distribution of +1 S.D. for length of lower limb. Arrows point to mean menarcheal age.

steeply at the first step but slants upwards till the age of 13 years followed by the change in direction along a horizontal course.

Velocity curve

The increments in mean values from one age to another are plotted in Figure 13. This velocity has the highest value of 4.66 cm from 9 to 11 years of age. The following age group registers a sharp fall, the increment being 2.53 cm from 10 to 11 years of age. The next age group hardly shows any variation from the preceding one. The velocity drops from 13 through 15 years of age. After this some irregularities are noticed, such as a rise at 16 a drop at 17, and again a rise at 18 years. It may be said that in general the increment after 14 years of age is rather insignificant.

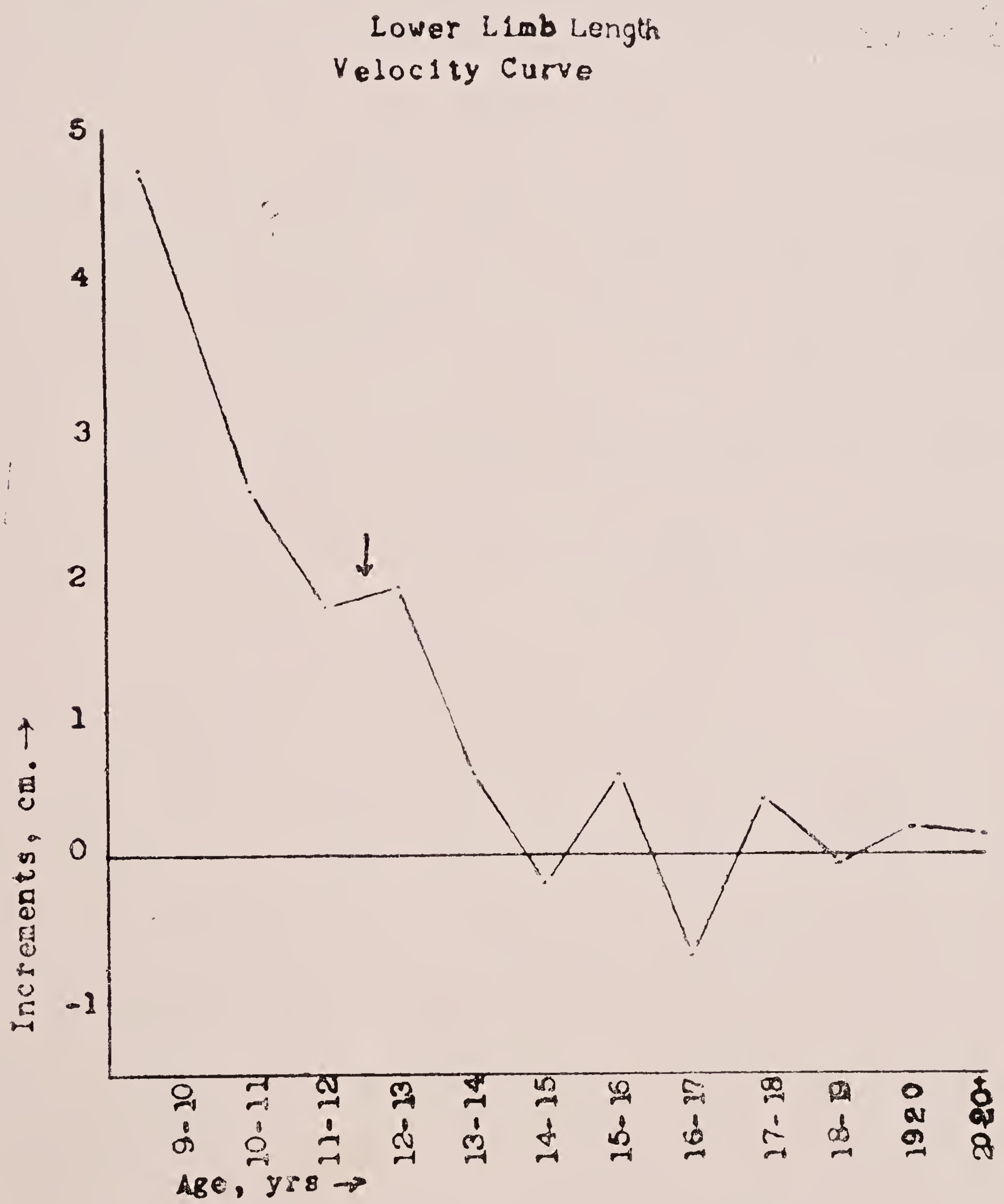


Fig. 13. Velocity Curve for length of lower limb. Arrows points to mean menarcheal age.

Standard deviation

The distribution of standard deviation of means for each age group, plotted in Figure 12, indicates that the spurt in the length of the lower limb is maximum at the age of 10 years. The

duration of this spurt is small. The standard deviations remain almost the same for the rest of the ages, except the 12-year group in whom it rises and the 17-year group in whom it drops.

Menarche and spurt

The mean age at menarche for the whole sample is indicated by arrows on all the three curves. The arrow on the growth curve shows the position when most of the rise in the curve is nearly completed. The increment curve shows that the highest increment is over about 2½ years before menarche. The curve for the standard deviation also points to the same findings : the spurt indicated in this curve is at the 10th year while the mean age at menarche is 12.48 years. Therefore the spurt is 2½ years in advance of the mean menarcheal age. To conclude, the spurt in the length of the lower limb is premenarcheal and precedes the menarche by 2½ years.

Comparison with other studies

The procedure of obtaining the length of the lower limb has been varied. Different workers on this problem have followed different landmarks. Some have taken the height iliospinale, some height trochanter and others, the calculated length from the stature and sitting height. The last method has been favoured by Newcomer and Meredith (1951) as, according to them, it has proved to be more reliable than the direct method. The number of studies on growth dealing with this dimension is not many. Moreover, of this limited number, different authors have followed different methods. As a result, there are only a few studies that are comparable. Only two studies which can be compared with the present work are those by Shuttleworth (1939) and Sabharwal *et al* (1966).

Shuttleworth has reported the stature and sitting height of the generalised group of girls studied at Harvard Research Centre, disregarding the age at maximum-growth group (M. G. age group). The lengths of the lower limbs have been calculated by the present investigator from the mean stature and mean sitting height for every age group, i.e., by subtracting the sitting height from the stature. These girls of the generalised series of Shuttleworth show about 3 cm shorter leg at the age of 9 years than the Bengalee girls of the same age. This inferior position, though to lesser degrees as the age increases, is maintained up to the age of 13 years. At 14, the Harvard girls show higher value. From 15 through 20 years of age they show about 1.5 cm longer legs than the Bengalee girls of the similar age groups. In general, the increments from one age to another between 10 and 15 years of age in Harvard girls are more than those in the Bengalees. After this age the Harvard set seems to have settled down. In other words, the increment is nearly stopped at 16 years of age but the Bengalee girls show settling down between 14 and 15 years of age, i.e., a year earlier than the former one.

The length of the lower limb of the Guatemalan girls is close to that of the Bengalee girls at

9, but shows considerably lower values from 10 through 12. At 13 they again come close but exceed the Bengalees at 14 by more than 1.5 cm. At 17 years of age the Guatemalan girls have more than 2 cm longer legs than the Bengalees. The former series shows lower rate of increase at the ages 10 and 11 years than the Bengalees at those ages. But while the increment slows down in the Bengalee girls from 10 through 14 years of age the Guatemalan girls show acceleration from 11 to 12, and retain a higher velocity than the Bengalees up to the age of 14 years. If the sharp lowering in the velocity (-2 cm) between 14 and 15 years of age is ignored, the Guatemalan girls are found to retain a higher velocity up to the age of 17 years, while the Bengalees show a tendency to stabilise from 15 years of age.

Summary

To sum up :

1 The spurt is premenarcheal and precedes the menarche by two and a half years.

2 The limb stabilises in length by 14 to 15 years of age.

3 It is generally shorter than that of the White girls of U.S.A. and of the Guatemalan girls.

4 The duration of effective growth in the lower limb of the Bengalee girls is one year shorter than in the other two samples.

5 From 9 through 12 years of age the Bengalees have comparatively longer lower limbs than the others.

6 The general velocity of growth is slower in the Bengalees than in the other two samples.

DIAMETERS

The growth of the body in the transverse direction is slow and less readily marked than in the vertical direction. The importance of the growth in this axis of the body has been recognised for long.

The Bengalee girls in the present sample have been measured at three sites of the body which are the representatives of the growth in the transverse direction. These three measurements are the bi-acromial diameter, chest breadth and bi-iliac diameter.

Bi-acromial diameter

This diameter gives the nearest approach to the body sturucture of the trunk because the points are at the end of bones that can be palpated and because the least amount of muscle and fat intervenes. The statistical constants of the measurement are shown in Table XIII against each age groups.

Table XIII : Statistical constants for Bi-acromial diameter of the Bengalee girls according to age

Age in years mid-point	Total number	Mean (centimeter)	S. E.	S. D.	Increments
9	34	28.08	.26	1.52	—
10	193	28.86	.14	1.92	0.78
11	198	30.64	.14	2.00	1.78
12	181	31.38	.14	1.88	0.74
13	199	32.42	.11	1.84	1.02
14	215	32.94	.09	1.44	0.52
15	215	33.38	.11	1.64	0.44
16	290	33.42	.11	1.84	0.04
17	236	33.54	.11	1.62	0.12
18	263	33.68	.09	1.54	0.14
19	226	33.76	.09	1.42	0.18
20	163	33.80	.09	1.26	0.04
20+	123	34.08	.16	1.34	0.28

Growth curve

The means of bi-acromial diameter plotted in Figure 14 show a curve typical of the physical growth. The gradual rise of the curve from 9 through 15 is followed by practically stabilised state from 16 through 20+, though a very slight rise in the line is noticed in the latter age groups.

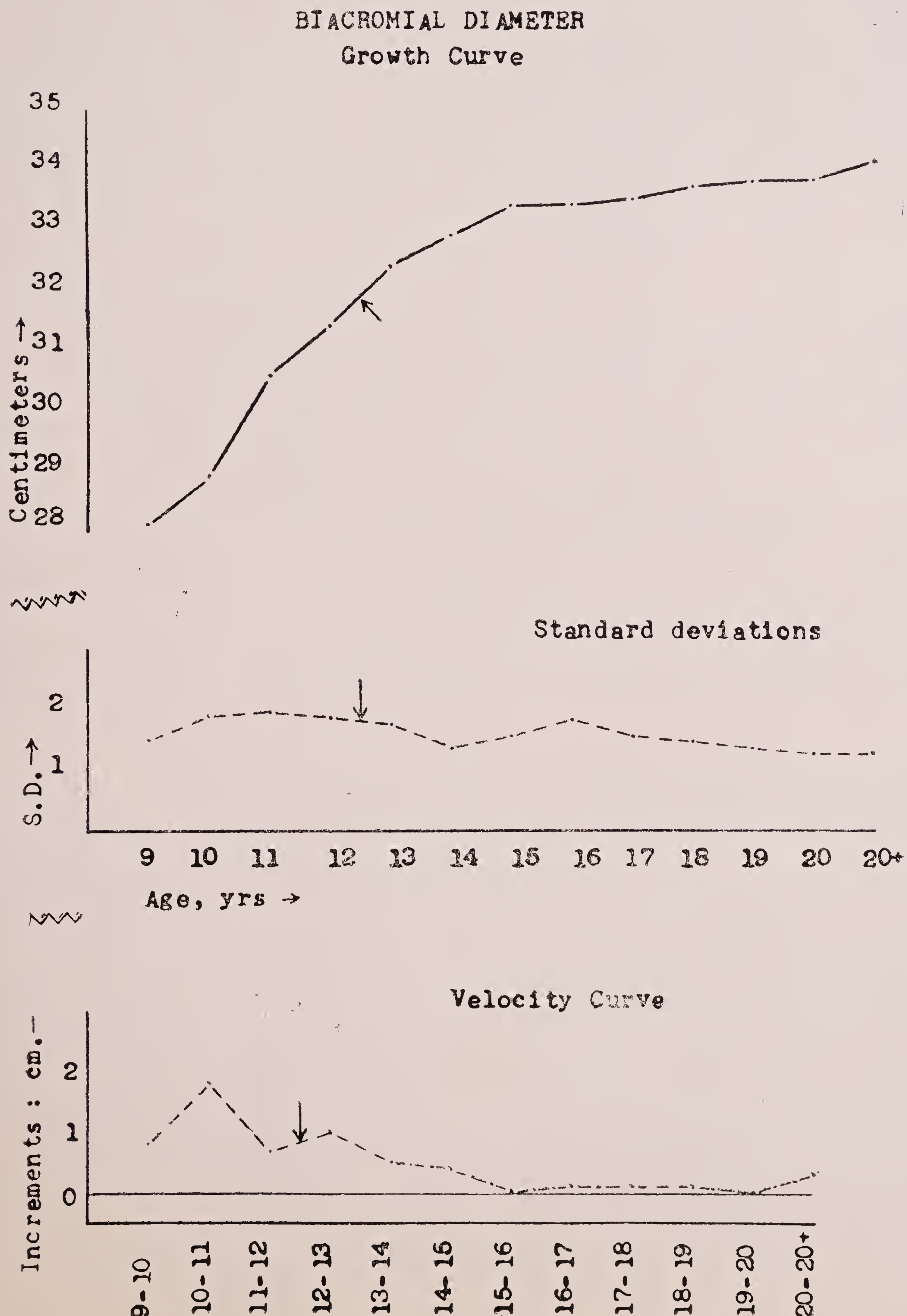


Fig. 14. Growth, Velocity Curves and distribution of +1 S.D. for bi-acromial diameter. Arrows point to mean menarcheal age.

Velocity curve

The max'mum rate of increase in the bi-acromial diameter takes place between 10 and 11 years of age as is shown in Figure 15. The velocity after 11 years of age gradually slows down till the age of 16 years. The velocity after 16 is inconspicuous.

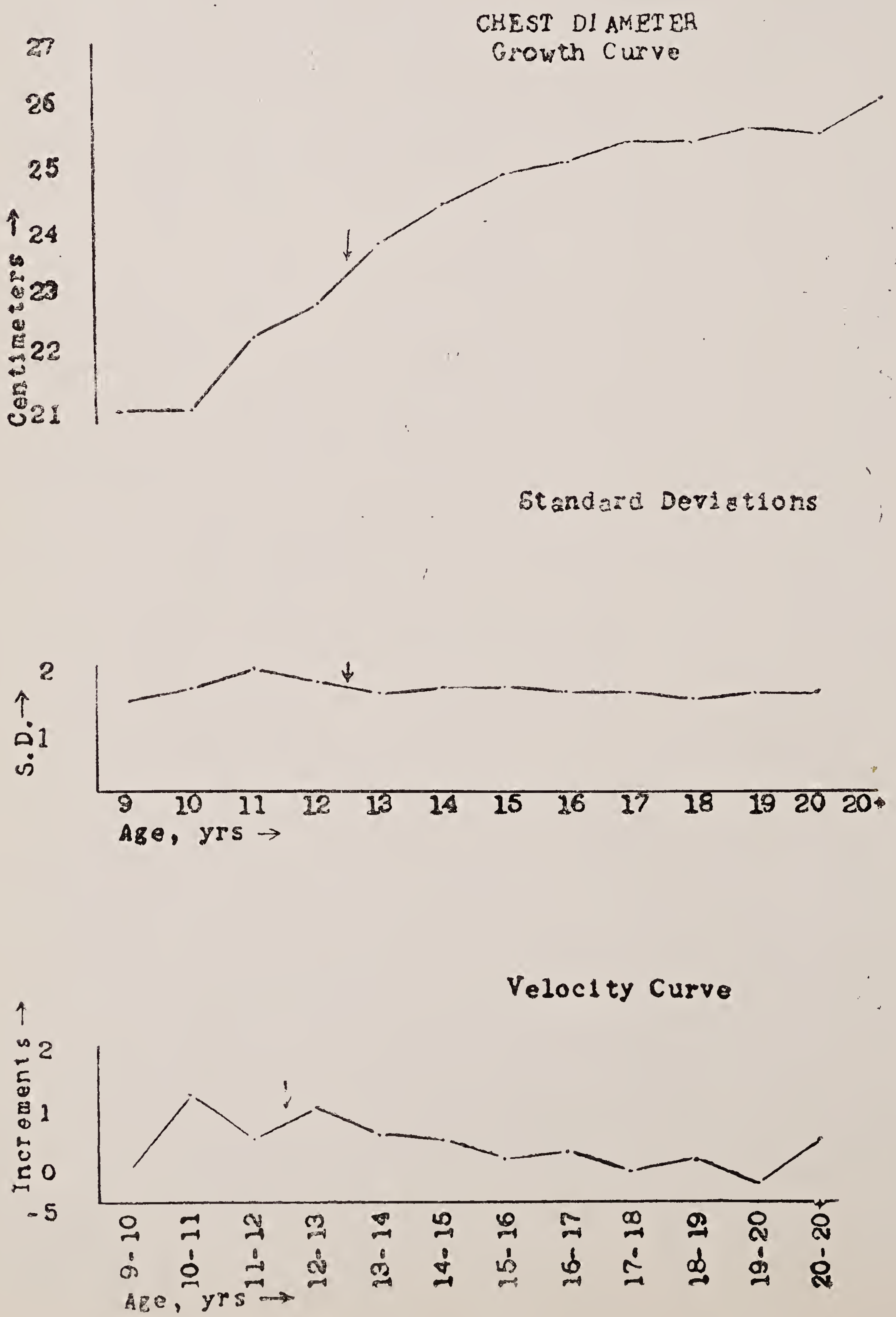


Fig 15. Growth, Velocity Curves and distribution of +1 S.D. for chest diameter. Arrows point to mean menarcheal age.

Standard deviation

The standard deviations of means for each age group in Figure 14 show some amount of rise from 10 through 12 years of age. The spurt in growth for this measurement is not clearly indicated by this curve, though some suggestion of the spurt cannot be ruled out.

Menarche and spurt

The arrows on the curves in Figure 14 indicate the mean age of menarche for the whole series. The curves show a rise of values before the menarche and this rise is one and a half years prior to it. This leads to the conclusion that the maximum increment or spurt, if it may be so termed in this case, is premenarcheal and occurs at the age between 10 and 11 years.

Comparison with other studies

The growth in the bi-acromial diameter beyond the age of 9 years for the present series has been compared with that of the White girls of Brush Foundation reported by Simmons (1944) and that of the Guatemalan girls reported by Sabharwal *et al* (1966).

The mean values in each age group in the Brush series are higher than those in the Bengalee girls for the corresponding ages. The difference at 9 years of age between these two groups is 0.68 cm. Gradually this difference increases and at the final age group or Brush series, i.e., at 17, they are 2.37 cm broader on the shoulder than the Bengalee girls of that age. While the Bengalee girls undergo deceleration after 11 years of age the Brush girls do not show any perceptible change in the velocity between 9 and 14 years of age.

The Guatemalan girls are nearly as broad across their shoulders as the Bengalee girls from 9 to 11 years of age, but in each successive age group up to 15 years the former group shows higher and higher values than the latter. At 18 the last age group of the Guatemalans, they come close to the Bengalees, showing continued growth of this parameter in the latter.

The mean bi-acromial breadths of the Negroes, Navajos and White girls of U.S.A. at the age of 19 and 20 years, as reported by Steggarda (1940), are 37.01, 35.45 and 35.61 cm respectively. These three groups, therefore, possess broader shoulders than the Bengalees at the corresponding ages.

Nagamine and Suzuki (1964) reported the mean bi-acromial breadth of 112 Japanese women belonging to the age groups 18 years to 23 years to be 34.55 cm. at the mean age of 21.3 years. The 20+ age group in the Bengalee series, when compared with these Japanese girls, show .5 cm narrower shoulders.

Summary

1 The bi-acromial diameter of the Bengalee girls increases slowly and more or less steadily up to the age of 15 years after which the increase is less perceptible.

2 The maximum velocity in this dimension between the ages 10 and 11 years is premenarcheal and is 1½ years prior to menarche.

3 The Bengalee girls have narrower shoulders at all ages than the White girls of U.S.A., the Guatemalan, the Negro, the Navajo and the Japanese girls.

Chest Diameter

Growth curve

Table XIV gives the statistical constants of the chest diameter (or breadth) for each age group in the present sample. Figure 15 shows the growth curve for this dimension. This curve travels almost diagonally up to the age of 15 years. After this age, the line shows the tendency to become more horizontal.

Velocity curve

The velocity curve in Figure 15 reveals that the increment between 9 and 10 is nil. But in the next year, i.e., between 10 and 11, it is the highest for the whole range of age groups. There is a lowering in the velocity between 11 and 12. The 13 year age group shows the second highest increase. After 13 years of age, the velocity gradually loses intensity as the age advances. Generally speaking, the stability in the chest breadth is reached by the age of 17 years. The increment after 20 years of age is probably due to excess in fat deposit.

Table XIV : Statistical constants for chest diameter of the Bengalee girls according to age

Age in years mid-point	Total number	Mean (centimeter)	S. E.	S. D.	Increments
9	34	21.14	.25	1.46	—
10	193	21.14	.12	1.66	0
11	198	22.31	.14	1.97	1.17
12	181	22.83	.13	1.70	0.52
13	199	23.81	.11	1.61	0.98
14	215	24.36	.11	1.68	0.55
15	215	24.87	.12	1.71	0.51
16	290	25.09	.10	1.63	0.22
17	236	25.35	.10	1.56	0.26
18	263	25.35	.09	1.52	0
19	226	25.59	.11	1.60	0.24
20	163	25.48	.12	1.60	—0.11
20+	123	26.01	.21	1.65	0.53

Standard deviation

The standard deviations of means of chest breadth plotted in Fgure 15 shows gradual rise from the age of 9 through 11 years. At thsis age the highest value of the constant is obtained. After 11, the values of this measure gradually fall and from 13 years of age onwards the line for the standard deviation runs uniformly parallel to the base.

Menarche and spurt

The average age of menarche, shown by the arrows on the curves, is later by one and a half years than the maximum increment or the spurt as the distribution of standard deviation shows. Therefore, for the chest breadth also the spurt in growth for this sample is premenarcheal.

Comparison with other studies

This dimension of the body has been measured in very few studies of growth. The only study dealing with this measurement which is available is the Harvard study (Shuttleworth 1939). The Harvard girls show lower values for all ages than the Bengalees. At the age of 9 years the Bengalees have nearly 2.5 cm broader chest and at 19 years the Bengalee series show 1.6 cm more in the mean chest breadth than those of the Harvard girls. It is neteworthy that all along their course the curves run almost parallel to each other and look much similar. In both, the maximum velocity is over by 13 years of age and beyond 16 or 17 years any increment in this dimension is hardly noticeable.

The measurement is taken between the sides of the chest—areas that are particularly fleshy and fatty. Attempt has been made to take this measurement without inserting any pressure. It may be mentioned that a very slight pressure will decrease the value of the measurement. It is not known how this measurement was taken on the Harvard girls. The difference in values between the two sets can therefore be hardly regarded as real, for the chance remains that the difference originates in the difference of techniques in taking the measurements.

Summary

In summing up, the following points may be mentioned :

1 The growth in the chest diameter is small, compared to most of the other dimensions of the body discussed before, and the growth is steady till the age of 17 years.

2 After the age of 17 years the dimension does not show any considerable increment.

3 The spurt in growth is premenarcheal and takes place at the age of 11 years, i.e., 1½ years prior to menarche.

4 The Bengalee girls have broader chest than the White girls from Harvard Growth Research Centre for all ages. This difference is probably due to difference in technique followed in the two studies because in all other measurements Harvard girls showed higher values at the late teen ages.

Bi-iliac Diameter

This measurement taken on the outer surface of the iliac crests gives the maximum breadth of the pelvic girdle. Pressure was applied on the instrument to reach as close to the crest as possible. The statistical constants of this measurement for the present sample are given in Table XV.

Growth curve

The means of the bi-iliac diameter of the girls in the present sample are plotted in Figure 16 against each age group. This turns out to be a typical growth curve. It rises gradually and steadily up to the age of 16 years after which age the curve runs horizontally except at the last age group when it shows a rise of about 0.7 cm. This rise is probably due to excess amount of fat deposit in this region which is difficult to displace even with pressure.

Velocity curve

The velocity curve in Figure 16 shows the highest increment (1.3 cm) at the age of 11 years and the second highest (1.0 cm) at 13 years. After 13 years of age the velocity gradually slows down as the age progresses and from 17 years of age the stabilised condition may be said to have been reached.

Table XV : Statistical constants for Bi-iliac diameter of the Bengalee girls according to age

Age in years mid-point	Total number	Mean (centimeter)	S. E.	S. D.	Increments
9	34	20.66	.27	1.62	—
10	193	21.46	.12	1.68	0.80
11	198	22.64	.15	2.06	1.18
12	181	23.45	.15	1.96	0.81
13	199	24.56	.12	1.70	1.11
14	215	25.06	.10	1.50	0.50
15	215	25.44	.12	1.72	0.38
16	290	25.82	.10	1.74	0.38
17	236	25.84	.10	1.54	0.02
18	263	26.00	.10	1.64	0.16
19	226	25.88	.11	1.64	—0.12
20	163	25.96	.12	1.50	0.08
20+	123	26.69	.17	1.45	0.73

Standard deviation

Figure 16 shows the distribution of the values of standard deviation for means of this dimension for each age group. The standard deviation is the highest at the age of 11 years, preceded by a gradual increase from 9 through 11 and succeeded by a gradual fall up to 13 years of age. From the age of 14 years this statistical constant hardly shows any change.

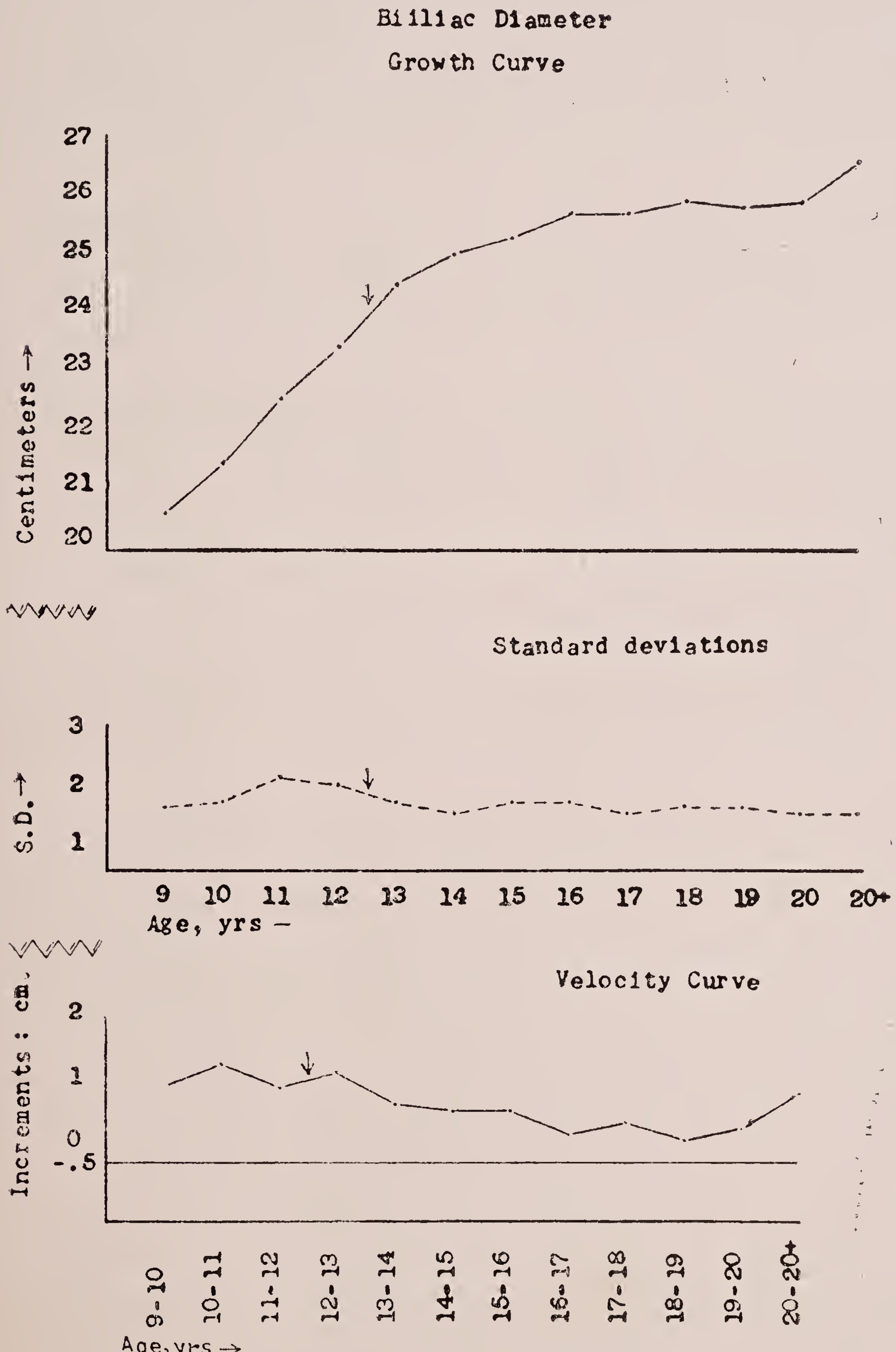


Fig. 16. Growth, Velocity Curves and distribution of +1 S.D. for bi-iliac diameter. Arrows point to mean menarcheal age.

Menarche and spurt

The spurt, as depicted by the standard deviation curve, takes place at the age of 11 years. The velocity curve also denotes the maximum rate between the ages 10 and 11 years. The mean

age at menarche for these girls is 12.48 years (indicated by arrows on the curves). Therefore the spurt in growth in the bi-iliac diameter takes place 1½ years before the mean age at menarche.

Comparison with other studies

The three studies compared with the present one for this dimension are those of Brush Foundation, Harvard Growth Research Centre and on Guatemalan girls.

The Brush Foundation series show higher values for the bi-iliac diameter in every age group than those in the Bengalees. At 9 the difference for this measurement in the two series is nearly a centimeter but at 17 the Bengalees have much narrower hips than the Brush Foundation girls; the difference exceeds 2.5 cm.

The rate of increase in the Brush series is higher than in the Bengalees from 9 through 17 years of age. But the patterns of the velocity as well as in growth in these two series are very much alike.

The growth curve for the Harvard series is very similar to the one for the Bengalees. The same is true for the velocity too. The Harvard series shows a higher rate of increment all through the ages from 11 to 19.5 years. From the age of 9 to 10 years the increment in the Bengalee series is a little higher. Both show that from the age of 17 years the increment is almost stopped.

The Guatemalan girls have broader hips than the Bengalees for each age group from 9 through 17 years. The Guatemalan girls show irregularities in the increments from one age to another.

The means for bi-iliac diameter of Steggarda's (1940) series of the Negro, Navajo and White girls are 27.62, 29.19 and 28.50 centimeters respectively for the mean age of 21 years. The Bengalees above 20 years of age with a mean of 26.69 cm have, therefore, narrower hips compared to the three above-mentioned groups. Nagamine and Suzuki (1964) reported the mean for this diameter in the Japanese girls of the mean age 21.3 years to be 27.41 cm. The Bengalee girls at this age have narrower hips than the Japanese girls too.

Summary

In summing up, the following features may be outlined :

1 The bi-iliac diameter in the Bengalee girls undergoes slow and steady increase up to the age of 17 years. After 17 the increase is almost nil except in the last age group of 20+ years.
2 The acceleration in the growth for this dimension takes place 1½ years before the mean age at menarche.
3 The Bengalee girls have narrower hips than the Whites at all ages and the Negroes, the Navajos and the Japanese at the age of 20 or above.

GIRTHS

The girth of any part of the body includes the bone, muscle and fat in that part. Therefore, in a growth study the measurement on the girths at different parts would deal with the sum of the growth of these three types of tissues. The arm and calf girths are typical representatives of this conception but the chest girth includes other organs in the region within the bony frame of the chest. In the present study, girths of chest, upper arm and calf have been considered.

Chest girth

The measurement was taken at the horizontal plane on the chest at the level of the articulation of the 4th pair of ribs with the sternum. A steel tape was used and readings were recorded in centimeters. The measurement was taken in between the inspiration and expiration. The statistical constants of this measurement are given in Table XVI.

Growth curve

The means of chest girth for the different age groups are plotted in Figure 17. This growth curve rises high and steep from 9 through 15 years of age. It takes a turn to the right at 15 and rises slowly up to 17 years. From this point for all practical purposes the curve runs horizontally.

Table XVI : Statistical constants of chest girth of the Bengalee girls according to age

Age in years mid-point	Total number	Mean (centimeter)	S. E.	S. D.	Increments
9	34	61.74	.79	4.64	—
10	193	63.30	.36	5.16	1.56
11	198	67.06	.45	6.36	3.76
12	181	70.02	.47	6.44	2.96
13	199	73.90	.41	5.80	3.88
14	215	75.46	.38	5.68	1.56
15	215	77.94	.41	6.12	1.48
16	290	78.54	.35	6.00	0.60
17	236	78.94	.37	5.72	0.40
18	263	78.26	.34	5.52	—0.68
19	226	78.70	.38	5.72	0.44
20	163	78.66	.41	5.08	—0.04
20+	123	79.23	.77	6.08	0.57

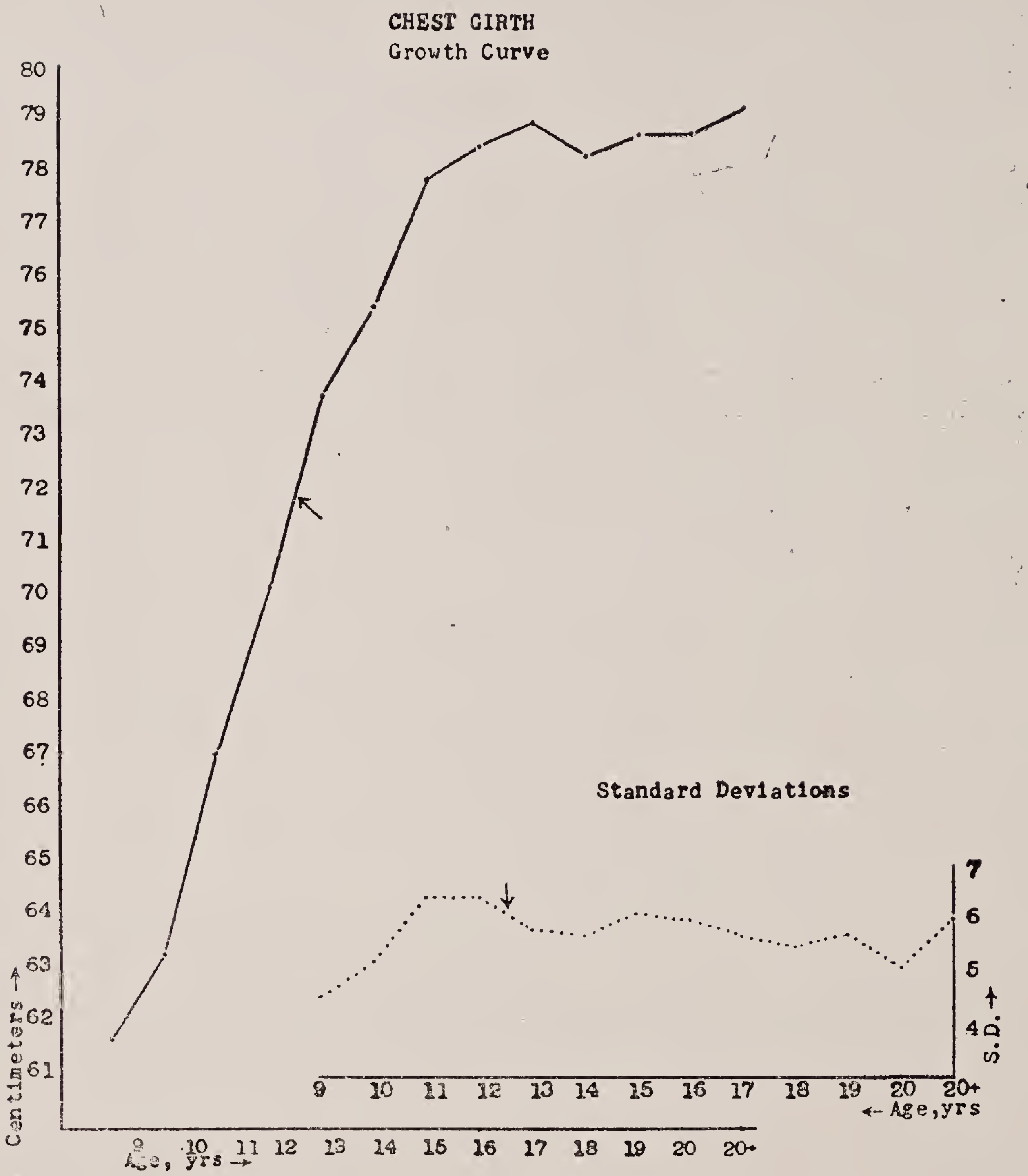


Fig. 17. Growth Curve and distribution of + 1 S. D. for chest circumference. Arrows point to mean menarcheal age.

Velocity curve

The increments from one age group to another are shown in Figure 18. The curve shows two peaks, one at 11 and another at 13. These two raised values are nearly the same. After 13 years of age, the velocity falls sharply in the next age group. Then it continues to fall gradually till the 17th year. The increments after 17 years, generally speaking, have stopped except in the last age group, where, like the breadth of the chest, the girth has also increased. This rise in the last group, as mentioned before, is probably due to extra fat deposit.

Standard deviation

Figure 17 shows the distribution of standard deviations for the means of chest girth against each age group. The line rises from 9 through 11. The age groups 11 and 12 years show nearly the same value for the standard deviation. From the age of 12 to 13 years it falls and, in general, maintains the same position all through the rest of the period.

CHEST GIRTH

Velocity Curve

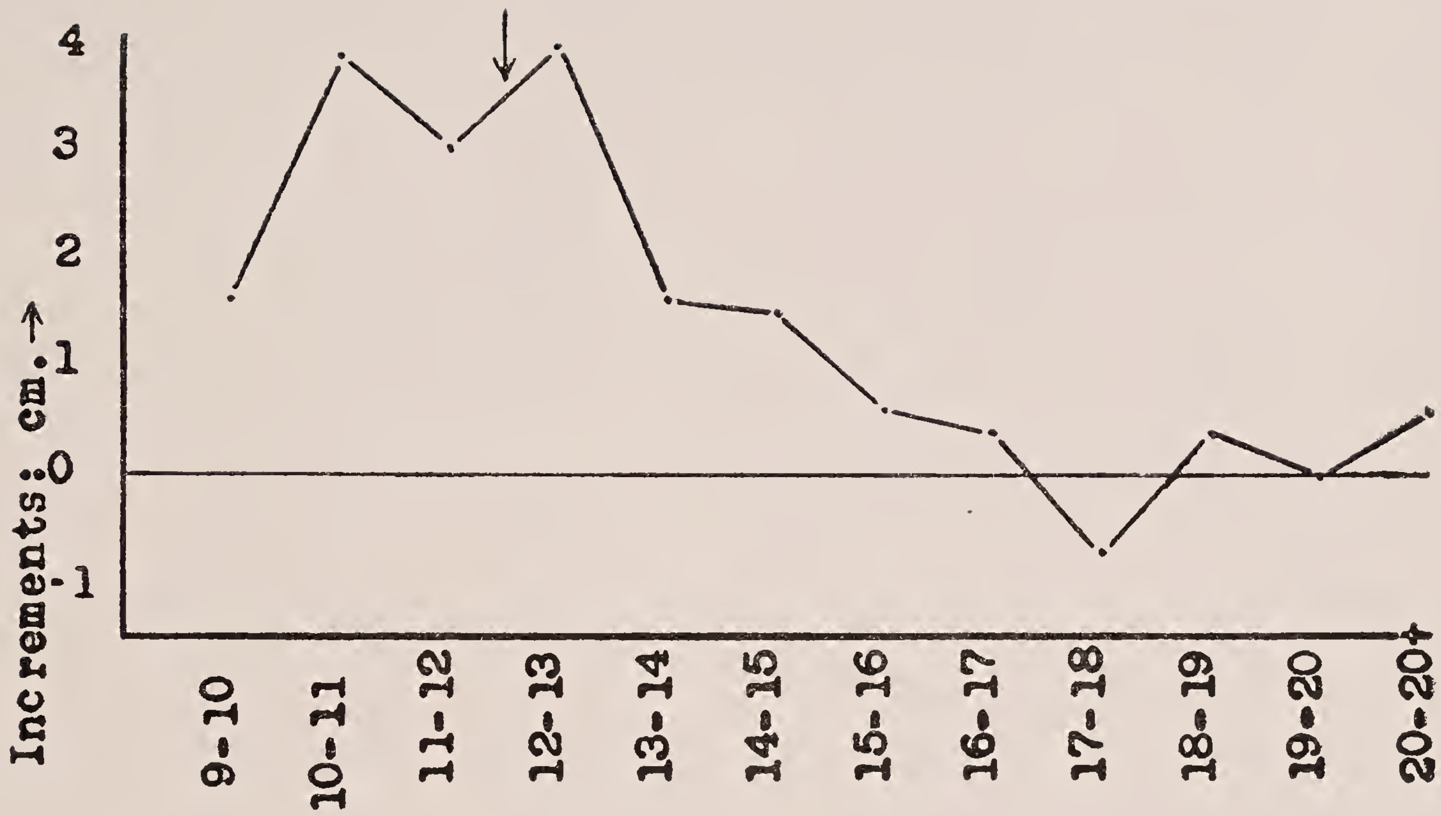


Fig. 18. Velocity curve for chest girth. Arrow points to mean menarcheal age.

Menarche and growth spurt

The arrows on the growth curve, the velocity curve and the standard deviation curve indicate the mean age at menarche. The spurt apparently takes place at the ages 11 and 12 years and is, therefore, premenarcheal. The position of the arrows in the other two curves, those of growth and velocity, is also in agreement with this finding.

Comparison with other studies

The chest girth of the present series has been compared with that of the Brush Foundation series and that of the Polish girls reported by Weissenberg (1911) and quoted by Martin (1928).

The Brush Foundation girls had been measured at both inspiration and expiration times (Simmons 1944, pp. 36 and 37). To make the Brush study comparable with the present one the means of these two measurements have been calculated for each age group between 9 and 17 years. The girls in the Brush study show nearly the same value at 9 and about 0.8 cm more at 10 years of age; thereafter the increments at 11, 12 and 13 years for this dimension in the Brush series are perceptibly smaller than those of the Bengalee girls at the corresponding ages. On the other hand, after 14 years of age the former series show greater increments up to the age of 17 years than the Bengalees.

For the Polish girls, the values for chest girth is from 10 to 17 years of age are smaller than those of the Bengalee girls. From 18 to 20+ years of age, however, the Polish series show nearly 1.5 cm higher values in chest girth than the Bengalees of those age groups.

The Polish girls show initially a marked increase between the ages 9 and 10 years ; comes down at 11, followed by a very steep rise at 12 years of age. From 12 years through 20+ years of age the Bengalee girls have lower rate of increase in this dimension than that of the Polish girls.

Summary

1 The chest girth in the Bengalee girls of the present sample grows markedly and rapidly from 9 years through 15 years of age, followed by a slower rate of increment up to the age of 17 years.

2 A stable condition is reached at 17 years of age ; after that the chest girth shows hardly any increment.

3 Acceleration in the growth of this dimension in the Bengalee girls takes place at 11 and 12 years of age and is premenarcheal.

4 The Polish girls have bigger chests than the Bengalees in late teens and early twenties, while in the younger age groups they have smaller chests compared to the Bengalees. The White girls of Brush Foundation centre have smaller chest girths through the ages from 11 to 17 years.

Upper arm girth

The girths of the left upper arm of the girls of the present sample were taken at midway between the acromion and olecrenon processes. The statistical constants are shown in Table XVII.

Growth curve

The means of the upper arm girth are plotted in Figure 19 against the respective age groups. This growth curve is comparatively flat than most such curves for other measurements on this sample. After an initial setback at the age of 10 years the curve slopes upwards till 16 years of age and then runs nearly horizontally with a slight upward trend at the last age group of 20+ years.

Velocity curve

Like most velocity curves of the present sample discussed so far, this curve (Figure 19) also has got two peaks, once between 10 and 11 and another between 12 and 13. After 13 years of age, the velocity shows a gradual fall till the age of 15 years. Between the ages 15 and 16 years the increase in this dimension is 0.6 cm but from 16 through 19 it is almost nil. After 19 years

of age the line again changes the direction to show increased rate up to the last age group. In other words, the girth of the upper arm has not stopped increasing even in the last group of this sample.

Table XVII : Statistical constants of upper arm girth of the Bengalee girls according to age

Age in years mid-point	Total number	Mean (centimeter)	S. E.	S. D.	Increments
9	34	17.80	.39	2.28	—
10	193	17.60	.13	1.88	—0.20
11	198	18.56	.15	2.18	0.96
12	181	19.26	.14	2.02	0.70
13	199	20.22	.13	1.78	0.96
14	215	20.88	.15	2.26	0.66
15	215	20.94	.13	1.92	0.06
16	290	21.40	.15	2.30	0.46
17	236	21.56	.15	2.30	1.16
18	263	21.54	.14	2.26	—0.02
19	226	21.66	.15	2.46	0.12
20	163	21.92	.18	2.30	0.26
20+	123	22.85	.35	2.73	0.93

Standard deviation

The standard deviations for means for each age group are plotted in Figure 19. Its distribution does not seem to indicate any acceleration in the growth of this measurement.

Menarche and spurt

The arrows in Figure 19 point to the mean age at menarche for this sample. The standard deviations, as has been mentioned before, do not show any spurt, so, no conclusion can be drawn as to the effect of menarche on the spurt in growth for upper arm girth. The velocity curve, on the other hand, shows rapid increase one and a half years before menarche.

Comparison with other studies

The girth of the upper arm of the White girls of Iowa city as reported by Meredith and Boynton (1937), and of the urban Guatemalan girls as reported by Sabharwal *et al.* (1966), are compared with that of the Bengalee girls in the present sample from Calcutta.

The White girls from Iowa city have much fatter arms all along the ages from 9 to 18 years than those of the Bengalee girls. The growth rates for these two series are similar upto 13 years, more in Iowa girls upto 15, thereafter again are similar.

The city girls from Guatemala have larger arm girths than the Bengalees and the Iowa girls. The high rate of increase in this dimension continues up to the age of 15 years in the Guatemalan series, i.e., two years longer than in the Bengalees.

The upper arm girth of the 21.3 years old (mean age) girls from Tokyo city, as reported by Nagamine and Suzuki (1964), shows the mean value as 23.24 cm and it is very similar to that of the Bengalee girls of the same age.

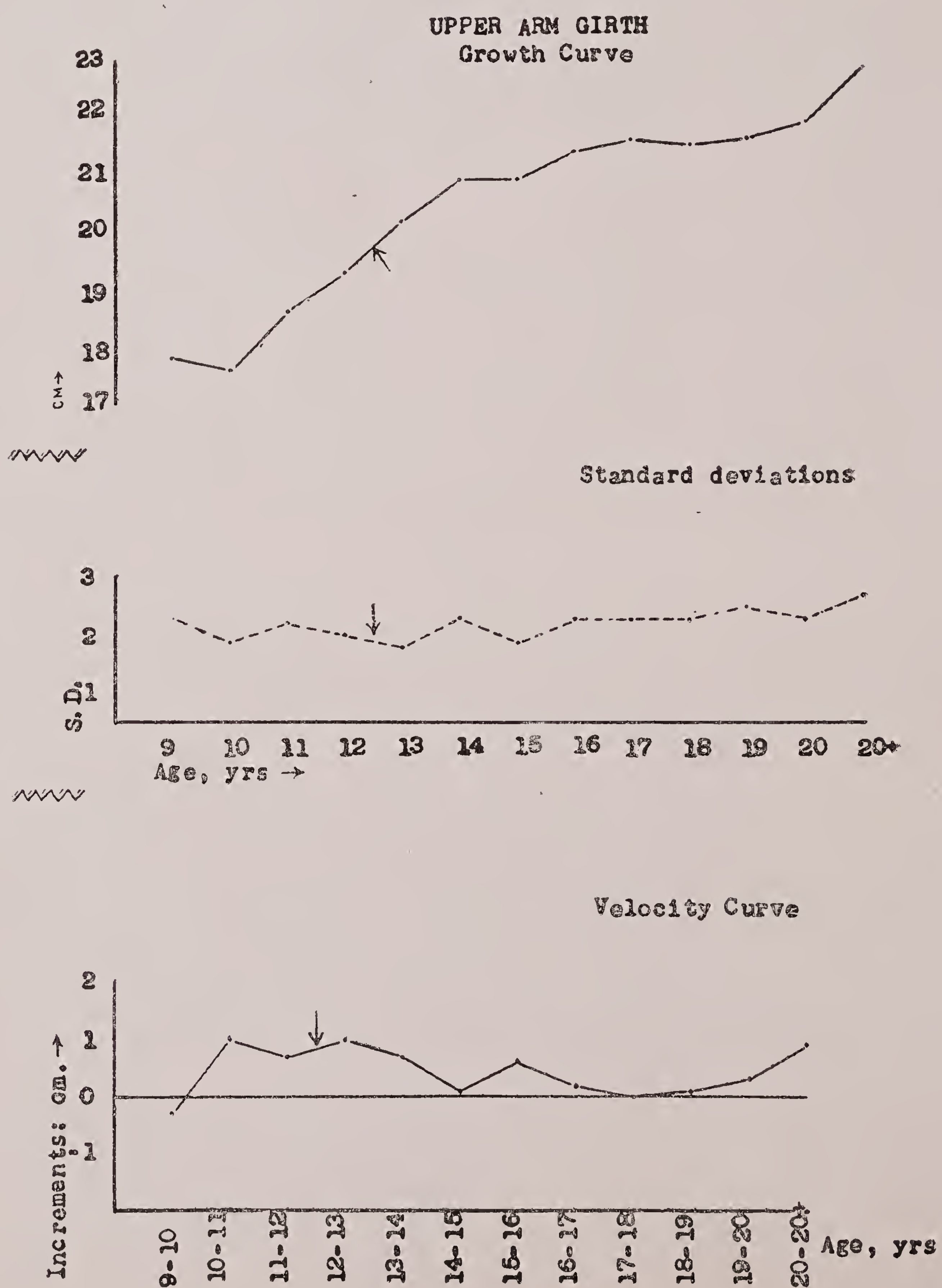


Fig. 19. Growth, Velocity curves and distribution of +1 S.D. for girth of upper arm. Arrows point to mean menarcheal age.

Summary

All these may be summed up as follows :

1 The upper arm girth in the Bengalee girls shows a slow and steady growth up to the age of 16 years.
2 The growth continues, though very slightly, till the last age group of 20+ years.
3 The maximum increment in this dimension takes place 1½ years before menarche. But no indication of premenarcheal spurt is noted from the distribution of the standard deviation.
4 Bengalee girls have slender arms compared to the White girls of U. S. A. and the girls of Guatemala.

Calf girth

For the purpose of obtaining the measurement of the calf girth each girl was asked to stand and rest her left foot on a stool. In this posture the calf muscles are in a relaxed condition. The measurement was taken with a steel tape on the left calf where the circumference is the greatest. The mean, standard error of mean and standard deviation together with the age-by-age increment for this measurement are shown in Table XVIII.

Growth curve

The means are plotted against the respective age groups in Figure 20. The curve does not rise perceptibly from 9 to 10, but thereafter it takes a course of continuous rise up to the age of 16 years. From 16 to 20 it runs horizontally while an upward thrust is noticed at the last age group.

Velocity curve

The maximum velocity is noticed at the age between 10 and 11 years (Figure 20). This high rate is maintained in the next two age groups. From 13 to 17 years of age, the velocity slows down gradually but consistently. Between the ages of 17 to 20 years there is practically no increment. Between 20 and 20+ years of age group the calf girth has an increment of 0.6 cm.

Standard deviation

The distribution of the standard deviation for the means are plotted in Figure 20 against each age group. The curve shows an abrupt rise at 11 years of age which is the highest for the sample. From this peak the line has a gradual fall through 13 up to 14 years of age. From the age of 14 years the value for this constant remains nearly stationary. Therefore, the spurt in this measurement takes place at 11 years of age.

Menarche and spurt

The arrows on the three curves show the mean age at menarche in Figure 20. The velocity curve as well as that of standard deviation indicates that the spurt in growth for the calf girth in this sample takes place at 11 years of age. The spurt is one and a half years before the mean age at menarche.

Table XVIII : Statistical constants of calf girth of the Bengalee girls according to age

Age in years mid-point	Total number	Mean (centimeter)	S. E.	S. D.	Increments
9	34	25.62	.39	2.20	—
10	193	25.84	.15	2.06	0.22
11	198	27.32	.19	2.80	1.48
12	181	28.34	.18	2.50	1.02
13	199	29.54	.19	2.76	1.20
14	215	30.28	.17	2.54	0.74
15	215	30.64	.19	2.90	0.36
16	290	30.96	.16	2.68	0.32
17	236	30.94	.17	2.66	—0.02
18	263	31.04	.15	2.54	0.10
19	226	30.96	.15	2.32	—0.08
20	163	31.02	.19	2.46	0.06
20+	123	31.71	.34	2.75	0.69

Comparison with other studies

The White girls from Iowa city as reported by Meredith and Boynton (1937), have calf girth larger by about a centimeter than that of the Bengalees at the age of 9 years. At 10, the Iowa girls measure nearly 1.5 cm more around the calf than the Bengalees. From the age of 10 to 13 years this difference remains almost constant. The difference increases from 14 through 18 years of age when the Iowa girls show much higher values. At 18 the Bengalee girls have calf girth smaller by 2 cm than the Iowa girls of that age.

The velocity of growth in Iowa girls is more compared to the Bengalees from the age of 10 to 17 years. While in the Bengalee girls the velocity starts slowing down from the age of 13 years, in the Iowa girls this stage comes at 14 years of age.

The means of calf girth of the Zurich girls from the age of 8.5 years to 14.5 years have been quoted by Martin (1928). The Zurich girls show lower values for calf girth than the Bengalees.

At 9 years of age the Bengalee girls measure about 1.8 cm more than these Swiss girls, but this difference gradually diminishes as the age advances, and at 14.5 years of age the latter series shows only 0.8 cm less in calf girth than the former series. The velocity of growth for the Swiss girls shows more irregular increments in each successive age group than the Bengalees. The intensity in increment in the Swiss girls diminishes at 13.5 years of age. Almost the same is the case with the Bengalees at the same age.

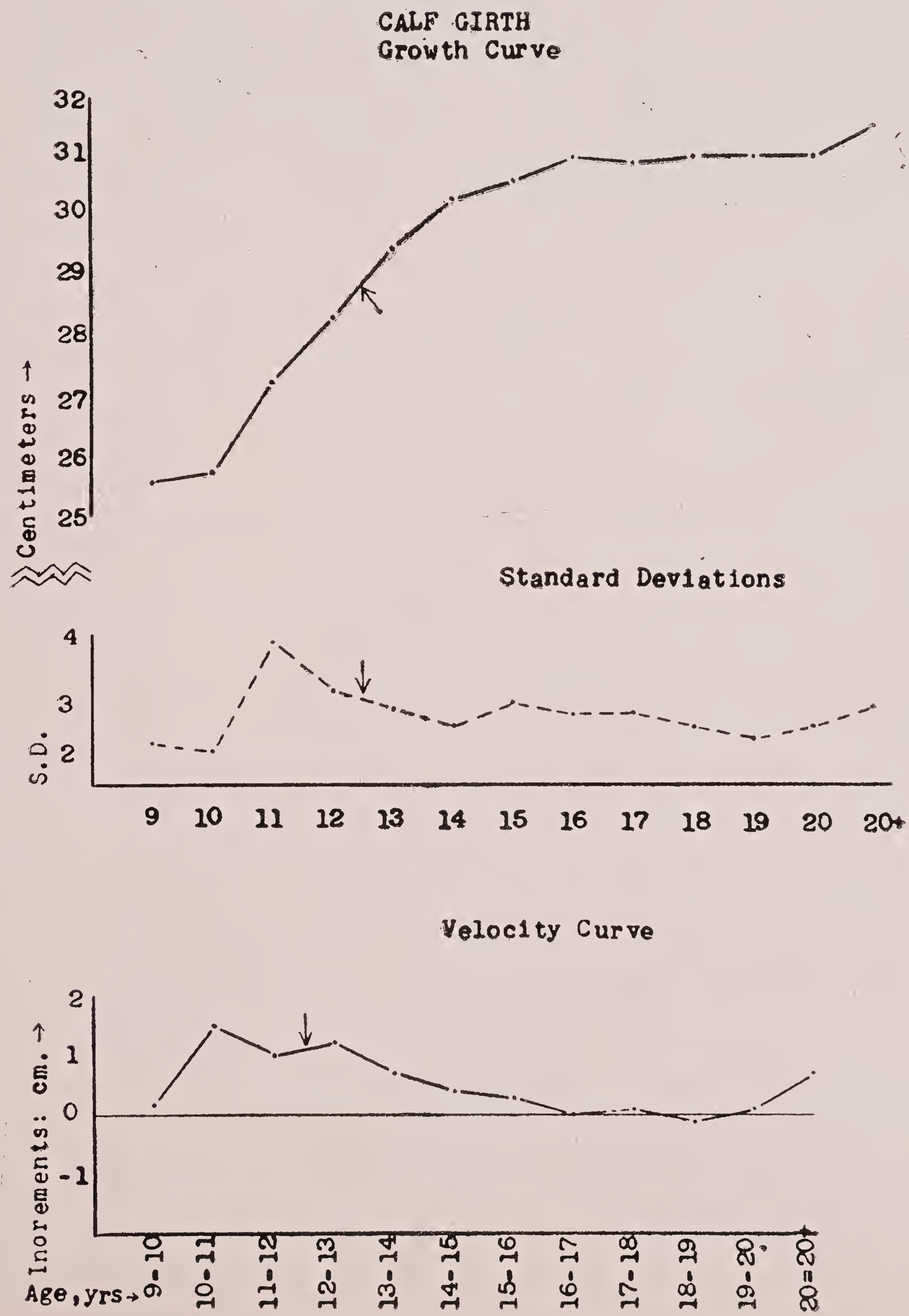


Fig. 20. Growth, Velocity curves and distribution of +1 S.D. for calf girth. Arrows point to mean menarcheal age.

The Tokyo city girls at the mean age of 21.3 years, as studied by Nagamine and Suzuki (1964), have a calf girth of 33.57 cm., while in the Bengalees the girth is smaller by about 2 cm at the same age.

The Smith College girls of U. S. A., reported by Steggarda *et al* (1929), measure 33.64 cm in calf girth at the mean age of 20.2 years which is also higher than that for the Bengalees at the corresponding age.

The Puerto Rican girls studied by Mitchell, and the U. S. girls studied by the American Child Health Organization quoted by Mitchell in his paper (1932)—show the mean values for calf girth of the 10 year old as 25.3 cm and 27.8 cm respectively. The Bengalee girls at this age register a value that is midway between these two.

Summary

To summarize, the calf girth of the Bengalee girls shows the following features :

1 It follows a typical growth curve.

2 The standard deviations show a spurt at the age of 11 years for this dimension.

3 This spurt precedes menarche by one and a half years.

4 The Bengalee girls have narrower legs than the American White girls but fatter legs than the Swiss girls at the earlier age groups.

5 At the age of 20 or above, the Bengalee girls have narrower legs than the White girls of America and the Japanese girls, but the Puerto Rican girls have narrower legs than the Bengalees.

SUBCUTANEOUS TISSUE

Finding out the thickness of the subcutaneous tissue is a comparatively recent and important problem for the physical anthropologists and for the workers in allied fields. The fat in the body as a whole is measured by displacement of water (Skerlz *et al.* 1953). But the subcutaneous fat is measured accurately by X-ray Photography (Stuart *et al.* 1940 ; Stuart, 1944 ; Reynolds, 1950 ; Baker *et al.* 1958). However, a simple way to find out the thikness of the subcutaneous tissue is to measure the skin pinch by means of a specially devised calliper, which is widely used now-a-days in mass studies (Stuart and Sobel, 1946 ; Cornfield, 1957 ; Malina, 1966 ; Fry *et al.* 1965). To make the results of the two types of investigations, one by X-ray and the other by skin pinch calliper, comparable, the skin pinch value which is the summation of two layers of subcutaneous fat must be reduced to the value of one layer as is found in X-ray Photography. This can be done, according to Skerlz (1953), by taking half of the skin pinch value minus 1 mm which is the thickness of the skin.

The subcutaneous tissue of fat deposit has been measured at three sites—subscapula, upper arm and calf—on each subject.

In contrast to the normal distribution of values on height and other linear measurements of the body, the distribution of skinfold thickness is highly skewed. As the skewed distribution is not thought to be suitable for further statistical analysis, each reading has to be transformed into its logarithmic value. This can be done according to the formula 100 x Log_{10} (reading in .1 mm. —18) as suggested by Edwards *et al.* (1955). The log transforms for skinfold measurements show a curve similar to that of the normal distribution.

When measurements on other dimensions are compared with the skinfold, log transforms have been used. But when musculature and bone thickness are discussed in terms of fat, direct readings have been taken into account for obvious reasons. The findings of the present series, when compared with those of other studies—either log transforms or direct measurements—whichever are comparable, have been taken into account. Tables and figures on fat measurements at each site are provided, both for log transforms and for direct reading, as no standard rule is followed by the authors.

Subscapular fat

The statistical constants of both log transforms and direct values of the skin pinch in the

subscapular region are given in Table XIX. The means of the transformed values with their S.D. are plotted in Figure 21 against the age groups.

Table XIX : The statistical constants of log transforms and direct values of the subscapular skinfold according to age

		Direct values				Log transforms			
Age in years mid-point	Total number	Mean (mm)	S. E.	S. D.	Increment	Mean (log units)	S. E.	S. D.	Increment
9	34	7.27	.51	3.00	—	176.18	4.31	25.16	—
10	193	7.40	.28	3.84	0.13	169.70	1.49	20.71	—6.48
11	198	9.15	.36	5.10	1.75	181.20	1.54	21.80	11.50
12	181	9.20	.32	4.25	0.05	183.60	1.39	18.81	2.40
13	199	11.15	.31	4.35	1.95	197.40	1.22	17.15	13.80
14	215	12.35	.36	5.35	1.20	197.18	1.24	18.22	—0.22
15	215	12.75	.39	5.85	0.40	200.80	1.34	19.57	3.62
16	290	12.78	.30	5.15	0.03	200.60	1.08	18.36	—0.20
17	236	13.85	.39	6.05	1.07	204.28	1.29	19.77	3.68
18	263	13.60	.36	5.90	—0.25	202.20	1.02	16.22	—2.08
19	226	13.95	.33	4.90	0.35	204.58	1.27	19.10	2.38
20	163	13.15	.39	4.95	—0.80	201.13	1.42	18.14	—3.45
20+	123	15.60	.64	7.15	2.45	209.15	1.83	20.32	8.02

Growth curve

The growth line shows a steady rise, though somewhat ladder-like, through the ages 9 to 17 years after which it tends to run horizontally. The rise for this dimension at the 20+ years of age is abrupt and steep.

Velocity curve

The increment of fat per year is shown in Figure 22. With regard to the rate of increase of fat in the subscapular region, it can be noted that there is a decline in velocity from 9 to 10 years followed by a sharp rise between 10 and 11 years of age. The fat increment between 11 and 12 years is notably small. Increment between 12 and 13 is the steepest, and after 13 years age group the increment of fat continues slowly, though, by fits and starts up to the age of 20 years. At the end of the journey between 20 and 20+ the girls seem to accumulate fat to a degree slightly less than that seen in girls between 12 and 13, but still the intensity is steep enough.

Standard deviation and growth spurt

The variability of the measurements, as judged by their standard deviations, is high in each

age group and no sudden and substantial increase of the same is noticed (Figure. 21) except, of course, in the earliest age group which can be explained as being a small sample.

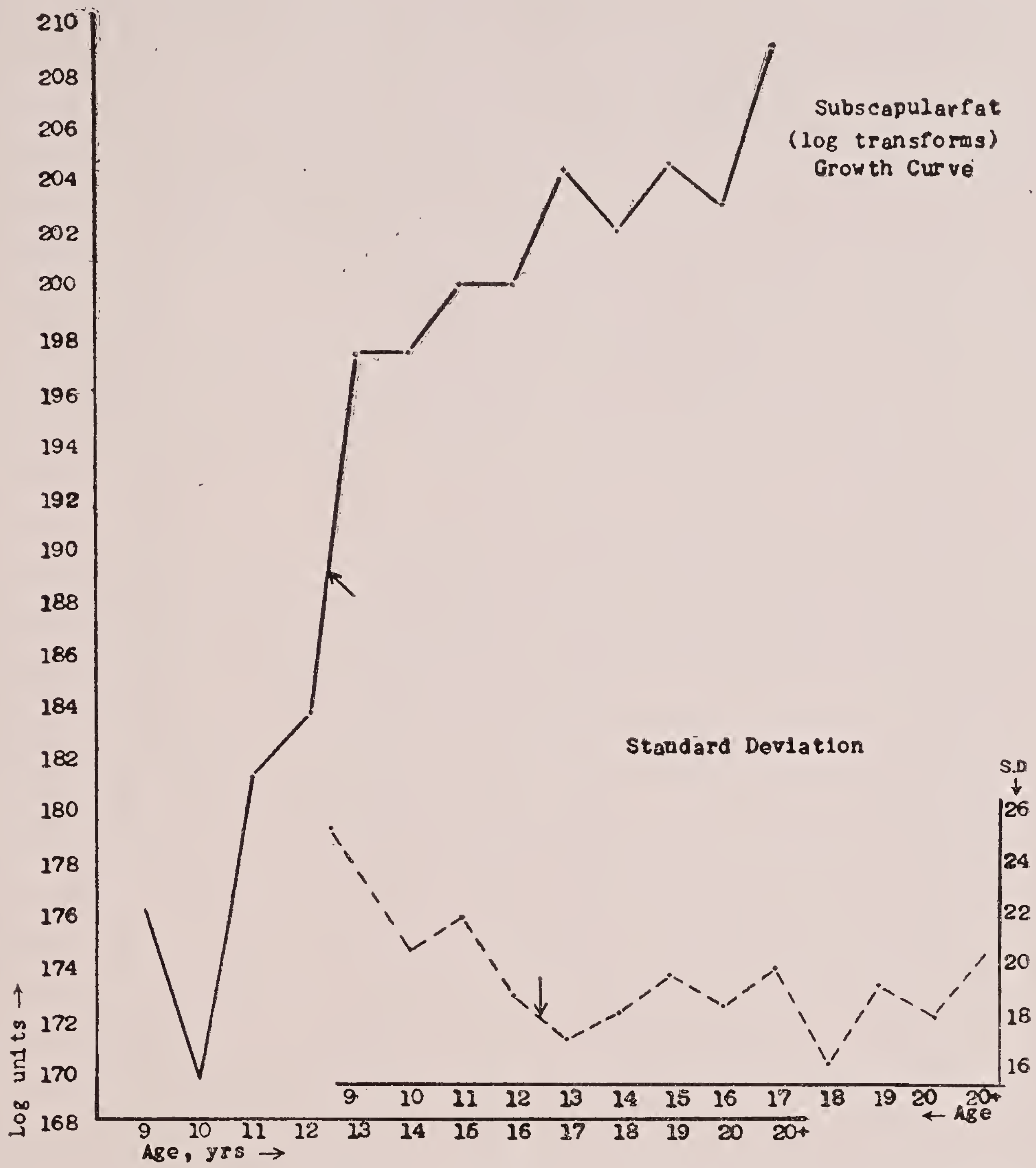


Fig. 21. Growth curve and distribution of + 1 S.D. of subscapular fat (log transforms). Arrows point to mean menarcheal age.

It is therefore not possible to deduce growth spurt in this character from the distribution of the standard deviations. The spurt is, however, clearly seen from Figure 22 on increment where the age 13 stands apart from others in showing a sudden and maximum rise of fat deposit in a year.

Menarche and growth spurt

The mean age at menarche is shown with an arrow in Figures 21 and 22. It will be seen that the mean age at menarche coincides with the period of maximum rise in fat accumulation in the 13-year olds.

The fat accumulation in the subscapular region occurs in a cyclic order, one year of deposit is followed by another of comparative rest (Figure 22). The latter sometimes involves denuda-

tion of accumulated fat. This has happened clearly at ages 10, 13, 18 and 20. There are two periods of maximum deposit of fat, one at the age of 11 and the other at the age of 13—the latter, the period of by far the heaviest deposit. Subsequently there are alternate periods of deposit—at ages 15, 17 and 19 ; but the rates are low as compared to those of the two early ages. The terminal age again shows a rapid deposit of subcutaneous fat.

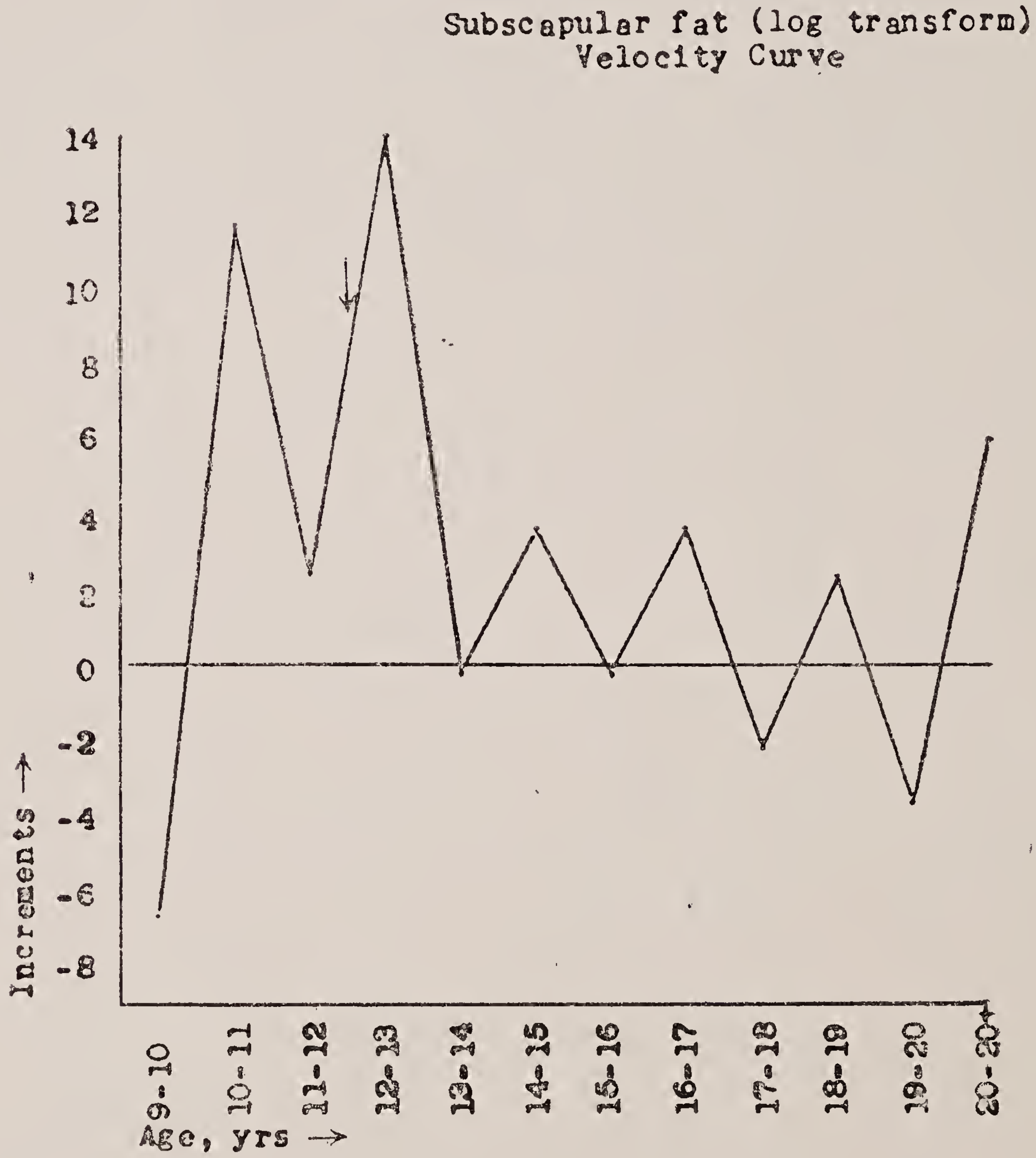


Fig. 22. Velocity curve for subscapular fat (log transforms). Arrow points to mean menarcheal age.

Comparison with other data

Skinfolds of the subscapular region of the Southern Chinese children of Hongkong have been reported by Fry *et al.* (1965). The combined (socio-economic) group for girls of this study, when compared with the present sample shows that the girls of Hongkong have less subscapular fat at every age beginning from 9 years to 16 years. The terminal ages of the Hongkong girls, however, show close approximation to the terminal ages of the present series. The similarity in the terminal ages between the two groups is due to the differential acceleration of fat deposit in the later ages, though the acceleration in the earlier ages in the two series remains the same. One other point of difference has to be mentioned. This is the decrease subcutaneous fat in this re-

gion in the Bengalee girls of 10 as compared to those of 9 years of age. This phenomenon is not observed in the Hongkong series where the 10-year olds have definitely more fat than the 9-year olds. Contrary to the present series, the Chinese data do not show any period where the quantity of fat is less than that of the previous age group.

Besides the data mentioned above, there are a few reports on the growth of fat in the subscapular region, but they do not include the range of ages as in the present series. These reports are therefore of limited value for comparisons to be made.

Garn and Heskell (1959) report the data of white girls in U. S. A. between ages 6.5 and 17.5 years. This study shows continuous increase from 6 to 11 years of age. The loss of fat found between 9 and 10 years in the subscapular region in the present sample is not ovserved in the American sample.

Malina (1966) reports two sets of data, the White and the Negro girls of U. S. A. The White girls show more deposit of subscapular fat than do the Bengalee girls for the age groups 9 through 12 years, and no decline between 9 and 10 years of age. The Negro girls, on the other hand, show less fat at 9, more at 10 and similar at 11 and 12 years of age, as compared to the corresponding ages of the Bengalee girls.

Upper arm fat

Growth curve

The skinfold values in millimeters and their log transforms are shown in Table XX. Only the log transform values by age groups are shown in Figure 23. The figure shows that starting with a value of 190 at the age of 9, the Bengalee girls of the present series lose considerable quantity of fat by the time they reach the age of ten, after which they begin putting on fat but the increment in the next year does not make them equal in fat content as they were at their 9th year ; in fact, in the next year, i.e., the 11th year, they lose some more fat. This means that the fact loss in the 9th year could not be recouped even in the two subsequent years. Relatively large deposit of fat occurs at the age of 13 when there is a gain of about 5 units. Thereafter the rate of deposit slows down. The growth line bends and becomes somewhat stationary in the 16th and the 17th year with the skinfold value of 201 units. There is a further period of fat loss in the 18th year but the rate of deposit accelerates during the terminal years 19, 20 and 20+.

Velocity curve

The pattern of increment in fat deposit is depicted in Figure 24. It will be seen that the increment pattern closely follows that of the subscapular region. Here also, after a period of negative rate of growth there are two periods of rapid accumulation, one at the age of 11 and the

other, heavier, at the age of 12. There is a cyclical nature of fat gain and loss in alternate years, though not to the degree as we have already seen in the case of subscapular fat.

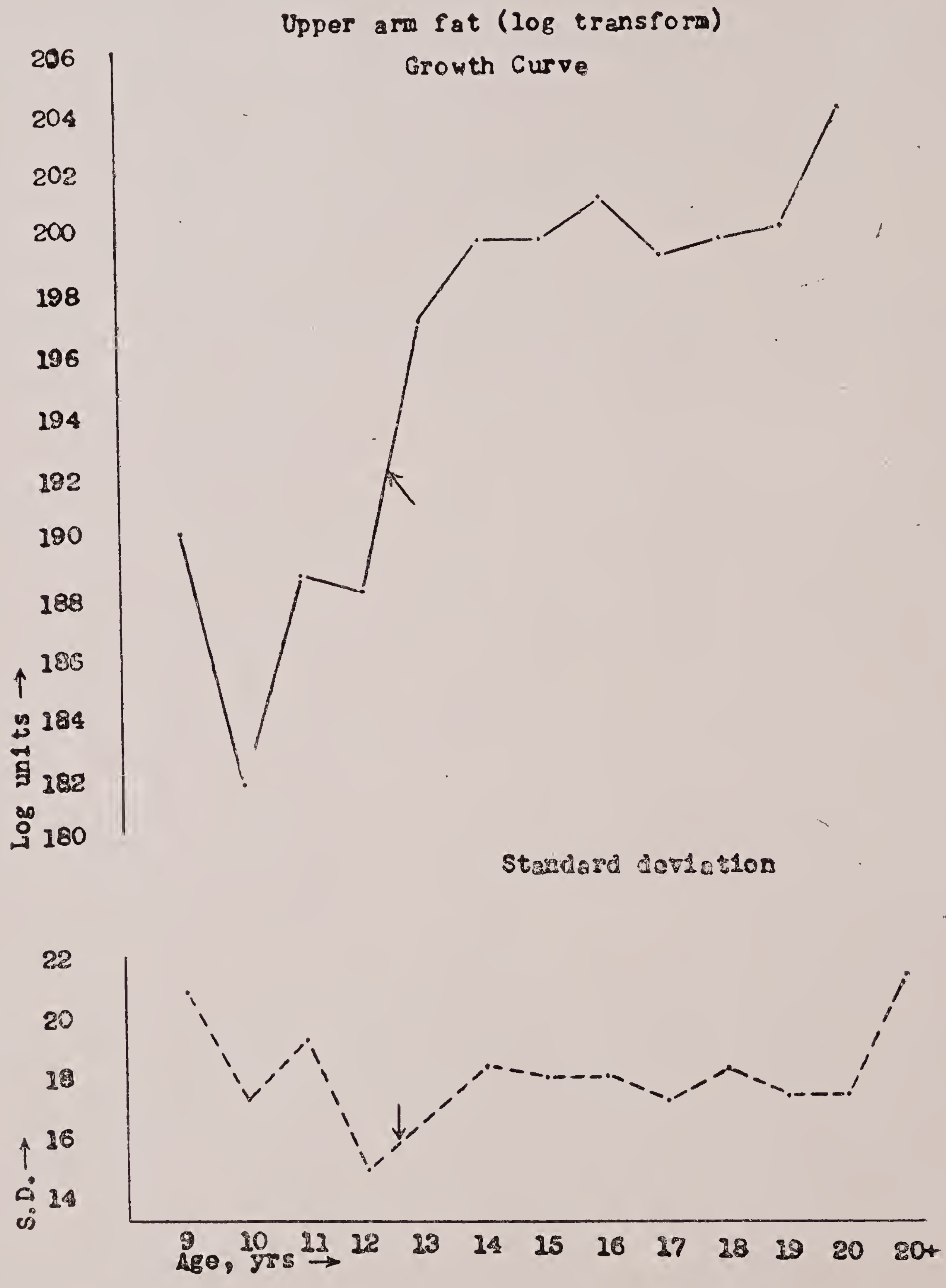


Fig. 23. Growth curve and distribution of + 1 S.D. for upper arm fat (log). Arrows point to mean menarcheal age.

Standard deviation and growth spurt

As in the case of subscapular fat, in the upper arm also the standard deviations are large. Similar in the various age groups, it shows deviations in the earliest and terminal one (Figure 23). We do not observe any sudden rise of the values of standard deviations to identify the period of spurt. The latter can, however, be seen clearly in Figure 24 where we can identify the spurt as occurring at 13 years of age.

Menarche and growth spurt

The mean age at menarche shown with arrows in Figures 23 and 24 coincides with the mid-point of maximum deposit of fat, that is, six months prior to the cessation of the spurt which culminates at the age of thirteen.

Table XX : The statistical constants of log transforms and direct values of the skinfold measurements of upper arm according to age

Age in years mid-point	Total number	Direct values: Mean (mm)	S. E.	S. D.	Increment	Log transforms: Mean (log units)	S. E.	S. D.	Increment
9	34	11.55	1.16	6.75	—	190.00	3.57	20.81	—
10	193	9.15	.25	3.45	—2.40	181.58	1.24	17.18	—8.42
11	198	10.45	.35	4.90	1.30	188.50	1.35	19.10	6.92
12	181	10.20	.38	5.20	—0.25	188.00	1.10	14.83	—0.50
13	199	11.70	.29	4.10	1.50	196.95	1.17	16.43	8.95
14	215	12.40	.33	4.85	0.70	199.56	1.23	18.03	2.61
15	215	12.50	.33	4.90	0.10	199.60	1.21	17.80	.04
16	290	12.69	.28	4.80	0.19	200.80	1.05	17.94	1.20
17	236	12.55	.28	4.40	—0.14	200.85	1.11	17.12	.05
18	263	12.75	.28	4.55	0.20	199.14	1.11	18.08	—1.71
19	226	12.65	.31	4.60	—0.10	199.56	1.14	17.18	0.42
20	163	12.55	.33	4.25	—0.10	200.03	1.34	17.15	0.47
20+	123	14.00	.55	6.05	1.45	204.02	1.95	21.66	3.99

Comparisons with other samples

The present sample has been compared with that of the Southern Chinese girls as studied by Fry *et al.* (1965) and mentioned before. The period of maximum growth occurs in the Bengalees from the 10th to the 14th year. In the Chinese, this period comes a year later, i.e., from the 11th to the 15th year. In contrast to the Bengalees, the Chinese girls show continuous growth, without any age group showing negative growth till the age of 17. Consequently, although the Chinese girls start with less quantity of upper arm fat than the Bengalees in the initial ages, they surpass the Bengalees after the 14th year. However, the same degree of fat loss is observed in the two series at the 18th year. The value for the Chinese series rises considerably higher than that for the Bengalees at 15 years of age and then it maintains this superior position. The Chinese girls are, therefore, less fatty on their arms up to the age of 14 years. But from 15 years of age onwards their arms are cinsistently fatter than those of the Bengalees.

The data on upper arm skinfold of the two economic groups of the Guatemalan girls, reported in millimeters by Sabharwal *et al* (1966), when compared with the Bengalee girls, show that the Bengalees hold a middle position between the two socio-economic groups from Guatemala, but they are closer to the lower group. While the Bengalees show stabilisation in this measurement from 14 years of age, the Guatemalan groups show upward trend up to the age of 17 years in the upper group and 16 years in the lower group.

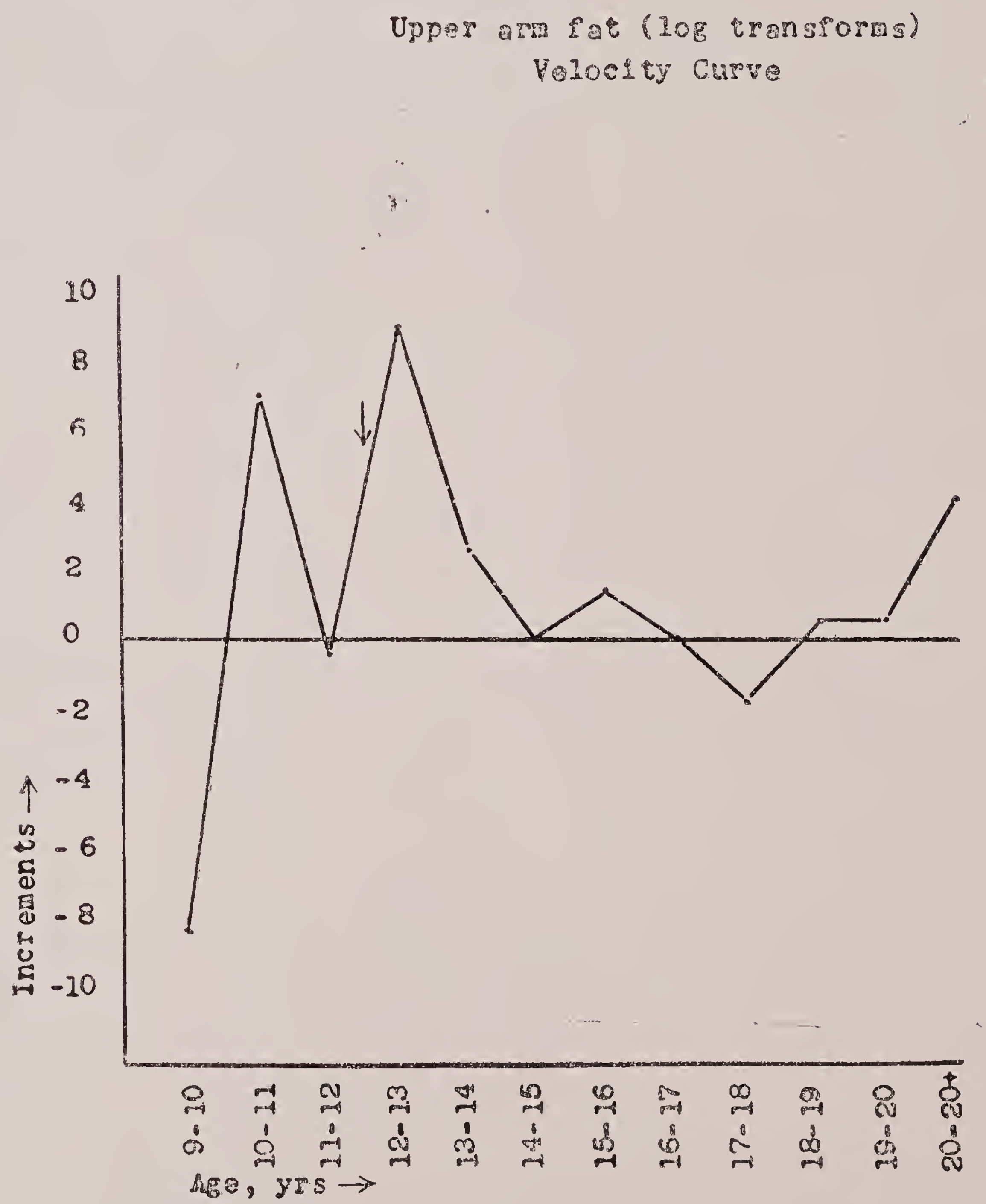


Fig. 24. Velocity curve for upper arm fat (log). Arrow points to mean menaacheal age.

The upper arm skinfold of the Negro and White Philadelphian girls as studied by Malina (1966) shows, when compared with that of the Bengalee girls, that the White girls have considerably higher values for all the age groups from 9 to 11 years. The Negroes also have a somewhat superior position than the Bengalees. Though at 11 years of age both the Negroes and the Bengalees have the same thickness of fat at the arms, at 12 the former show more fatty arms than the latter. In these two last-mentioned groups the fat in the arms decreases between 9 and 10 years of age but in the Whites it does not.

Calf-fat

The statistical constants of both log transforms and direct values of the skinfold in the calf region are given in Table XXI. The means of the transforms with their standard deviations are plotted against the age groups in Figure 25. After a loss initially at the age of 10, a steady increase is seen without any period of rest till the age of 16 years. Then there is a rest for two years after which further accumulation occurs in the two terminal age groups. The pattern of fat deposit in this region, being more regular, is different from that of the subscapular or upper arm region.

Standard deviations and growth spurt

An examination of the standard deviation of each group in Table XXI and Figure 25 shows that they vary from 15.94 to 19.72 which include the two terminal age groups. There is therefore no sure indication that here the standard deviations can give us the clue to the identification of growth spurt. As seen from Figure 26 where rates of insrements are given, the age group of 10 years appear to coincide with the spurt. In this matter also the growth pattern of the calf fat is different from those of the other two regions where clear indication of the spurt is seen at the age of 13 years. In view of this, it may not be justified to term the rise of values at 10 years as true spurt.

Table XXI : Statistical constants of log transforms and direct values of skinfold measurements of calf according to age

		Direct values				Log transforms			
Age in years mid-point	Total number	Mean (mm)	S. E.	S. D.	Increment	Mean (log units)	S. E.	S. D.	Increment
9	34	11.70	1.38	8.10	—	198.50	3.25	18.92	—
10	193	10.90	.31	4.35	—0.80	192.88	1.23	17.29	—8.42
11	198	13.50	.47	6.65	2.60	202.40	1.37	19.30	6.92
12	181	14.50	.46	6.15	0 55	205.10	1.36	18.30	—0.50
13	199	15.05	.41	5.85	1.00	209.20	1.23	17.41	8.95
14	215	15.55	.49	7.30	0.50	213.09	1.32	19.39	2.61
15	215	19.95	.48	7.05	0.40	214.40	1.27	18.65	.04
16	290	17.65	.42	7.15	1.70	216.10	1.10	18.80	1.20
17	236	16.90	.44	6.80	—0.75	214.53	1.14	17.55	.05
18	263	17.70	.45	7.35	0.80	215.42	1.15	18.71	—1.71
19	226	17.40	.49	7.20	—0.30	215.88	1.22	18.38	0.42
20	163	17.80	.51	6.45	0.40	217.45	1.25	15.94	0.47
20+	123	19.80	.69	7.60	2.00	221.34	1.78	19.72	3.99

Age at menarche and growth spurt

It has been seen that in the upper arm and subscapular region, the midpoint of the maximum growth period, i.e. the age of 12 years 6 months, coincides very closely with the mean age at menarche of the whole series. The calf region is, however, distinguished by no such close association, 12 years 6 months being coincident with only a minor rise of values (Figures 25 and 26.

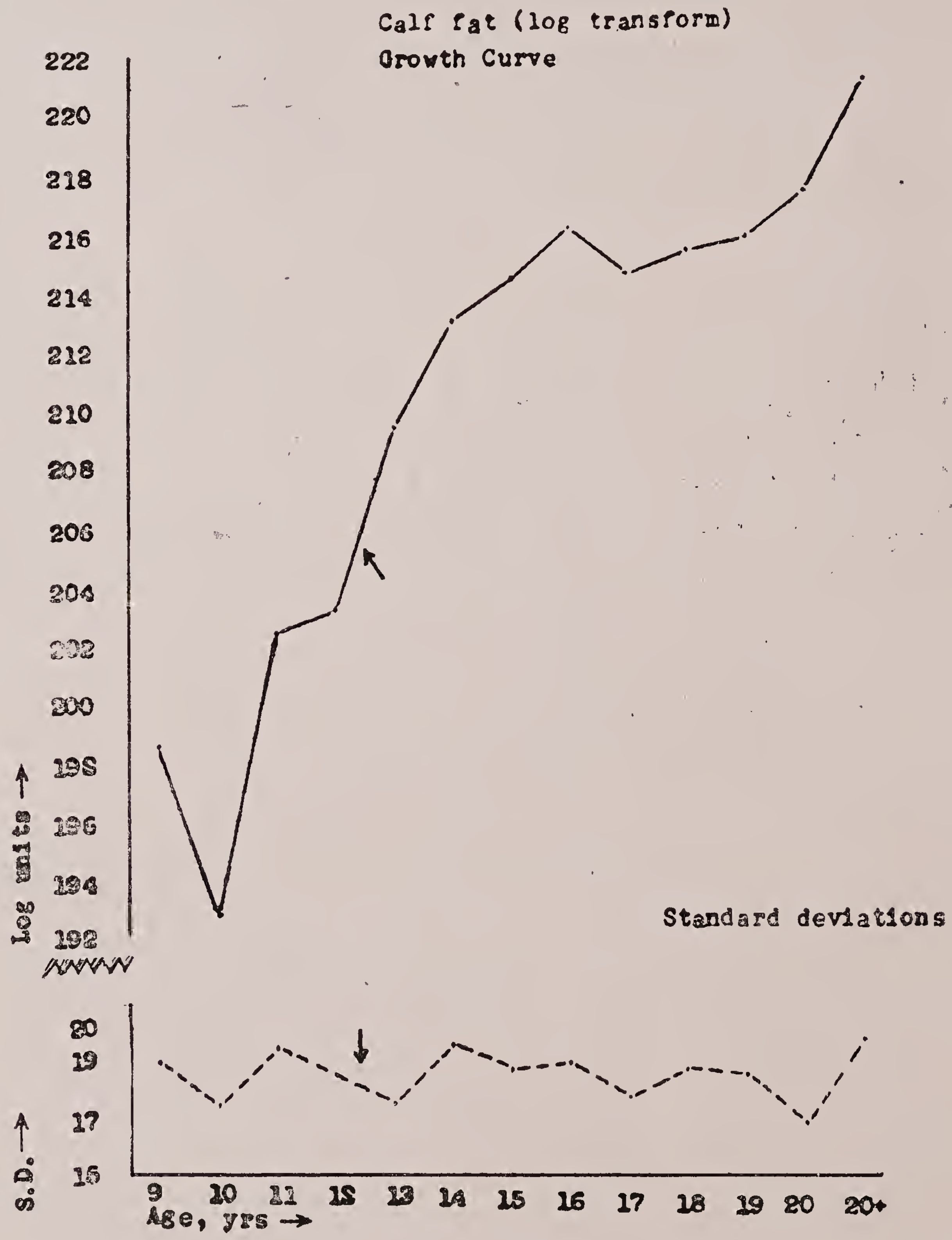


Fig. 25. Growth curve and distribution of + 1 S.D. of calf fat (log). Arrows point to mean menarcheal age.

Comparisons with other samples

We shall have to turn again to Fry's data on Chinese girls mentioned before, for comparison with the present sample. Unlike those of the subscapular and the upper arm, the fat measurements of the calf region of the Chinese show considerably smaller values than those of the Bengalees in all the age groups. It will be recalled that the Chinese girls have more or less the

same value for the subscapular region as the Bengalees at the terminal ages of 17 or 18 years, and higher value than that of the Bengalees at this age for the upper arm. For both the sites, however, the values for the Chinese girls are much lower than those of the Bengalees at the age of 9 years. In the Chinese series, the growth of fat in the calf region is more or less of the same type as those in the Bengalees and it continues to grow till the age of 17 years with a setback at 15. However, in spite of the similarity of the pattern between the two series, since the Chinese started with a lower value, they do not reach anywhere near the values of the Bengalees. Thus, the highest value reached by the Chinese is 205 units at the age of 17 years. This value is reached by the Bengalees at the age of only 12 years. At 17, the Bengalee value is 215 units. Even the Chinese of high socio-economic group do not compare favourably with the Bengalees of the present series.

The radiographic study on the fatty tissue of the calves of the Philadelphian girls by Malina and Johnston (1967) shows that the lateral fat in this region for these girls between 9 and 15 years of age have much higher values than that for the Bengalee girls at the corresponding ages.

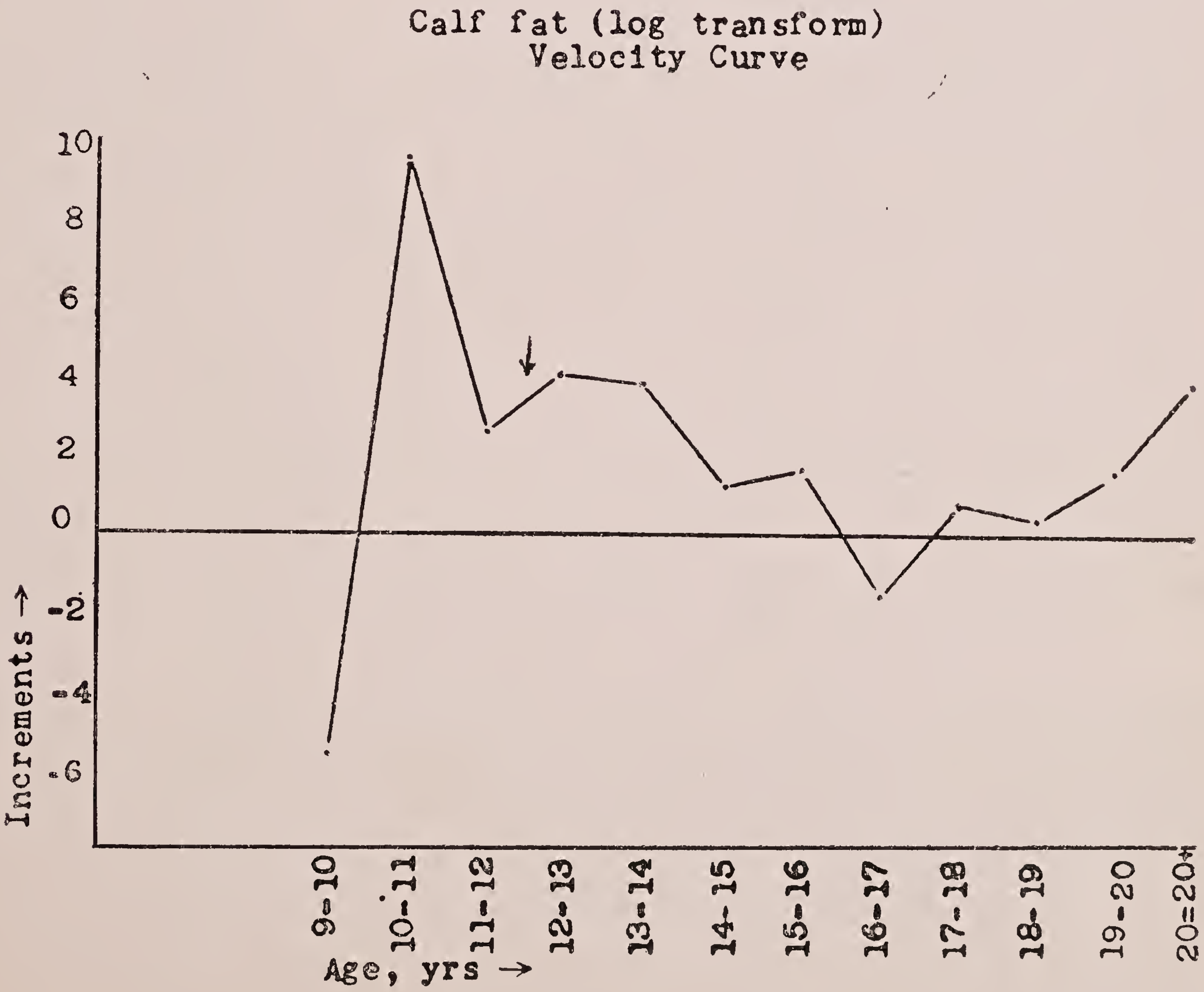


Fig. 26. Velocity curve for calf fat (log). Arrow points to mean menarcheal age.

At the age of 9 years the Philadelphian girls show about 18 mm. more fat thickness on the calf than the Bengalee girls of the same age. This difference is more or less maintained till the age of 14 years, although at ages 11 and 12 the difference is slightly higher. The two series come closest at 14 years of age. Between 14 and 15 the American girls show a sharp rise while in the Bengalees the rise comes a year later and with less intensity. As a consequence, the difference at 15 years of age between the two sets is nearly 22 mm., i.e., a little more than what they started with at the age of 9 years.

Reynolds (1950) reported the data on the thickness of the calf fat in American White girls. This series, shows the values as less fluctuating, more gradual and steady between the ages 8½ to 15½ years than is the case with the Philadelphian girls. The 9-year olds in the former series are fatter on their calves by 15 mm. than the Bengalees of that age. But the difference is almost negligible at the higher ages, i.e., from 16 to 18½ years. The fluctuations in these last-mentioned ages in both Reynold's and the present series are also comparable. The American girls in Reynold's study show closer similarity to the Bengalees than the girls in Malina and Johnston's.

Skinfold values in general

The means of the log transforms of the subcutaneous fat measured at the three sites for the ages 9 through 20+ years are plotted in Figure 27. The increments in means between each successive ages are plotted in Figure 28. From these two figures it is clear that (1) the fat deposit diminishes from 9 to 10 years of age. This drop is the sharpest in the upper arm while the calf and subscapular fat reduce at almost the same intensity. (2) The premenarcheal acceleration is conspicuous for all the three regions—it is most marked in the subscapular, followed by the calf and than by the upper arm. (3) The acceleration is considerably reduced between ages 11 and 12 years which is succeeded by a marked increment between 12 and 13 years of age. These features are common to all the sites measured. (4) After 13 years of age there exist fluctuations in the velocity in the fat deposit at all these sites but it is prominent at the subscapular and the least at the upper arm. (5) After 20 years of age the fat deposit is considerably more than in the preceding ages.

Novak (1963) has used the sum of skinfolds to show the trend of fat deposit in Minnesota boys. Accordingly, the sum of skinfolds for this series has been calculated from the means of the calliper readings at the three sites for each age group. Figure 29 shows the percentage distribution of skinfolds at the three sites in relation to total fat. Both the total fat and the percentages have been converted into whole numbers to give a regular picture. The figure clearly shows that the calf and the subscapular fat decreases while the arm fat increases at the beginning. At the intermediate stages the calf fat first increases and then decreases in proportion to others. The fat at the back shows increase while the arm fat shows a decrease. At the last stage, the arm fat decreases, the back fat increases and the calf fat remains stationary. This may lead to the con-

clusion that in the post-menarcheal deposit of fat (from the age of 13 years when the ,mean weight is 40 kg.), the increase in total fat is mainly due to the increase in the subscapular fat deposit which is proportionately higher than that of the arm and the calf.

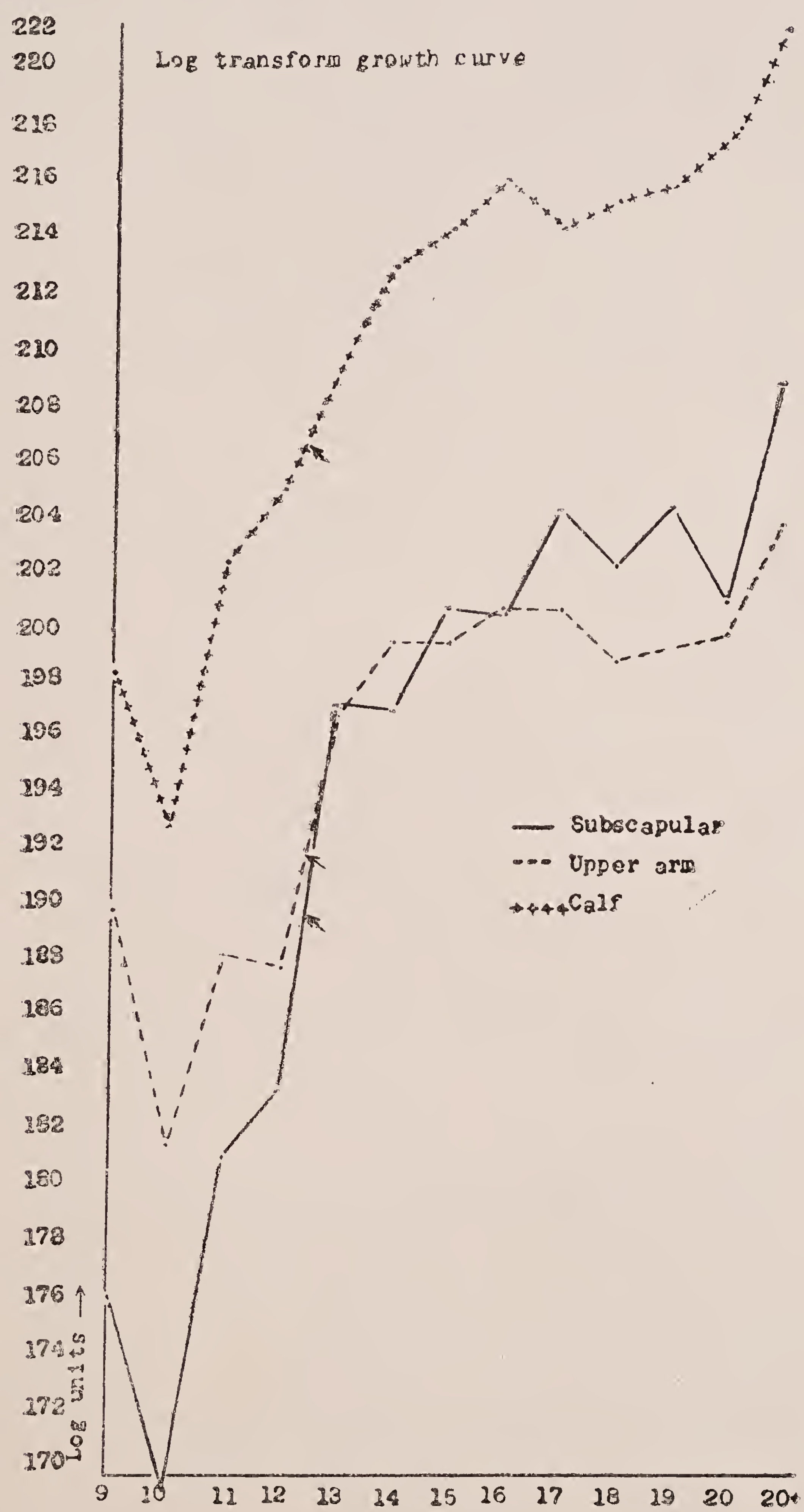


Fig. 27. Growth curves for fat (log transforms) at three sites.

In general, as Figure 29 shows, the calf fat has a superior position all along while the subscapular fat has the lowest position to start with but the rapid increase has given it a second

position at the later stage. The arm fat , on the other hand, has an intermediate position at the early ages and the lowest position at the later ages. Moreover, the calf and the back fat show proportionately more increase than the arm fat.

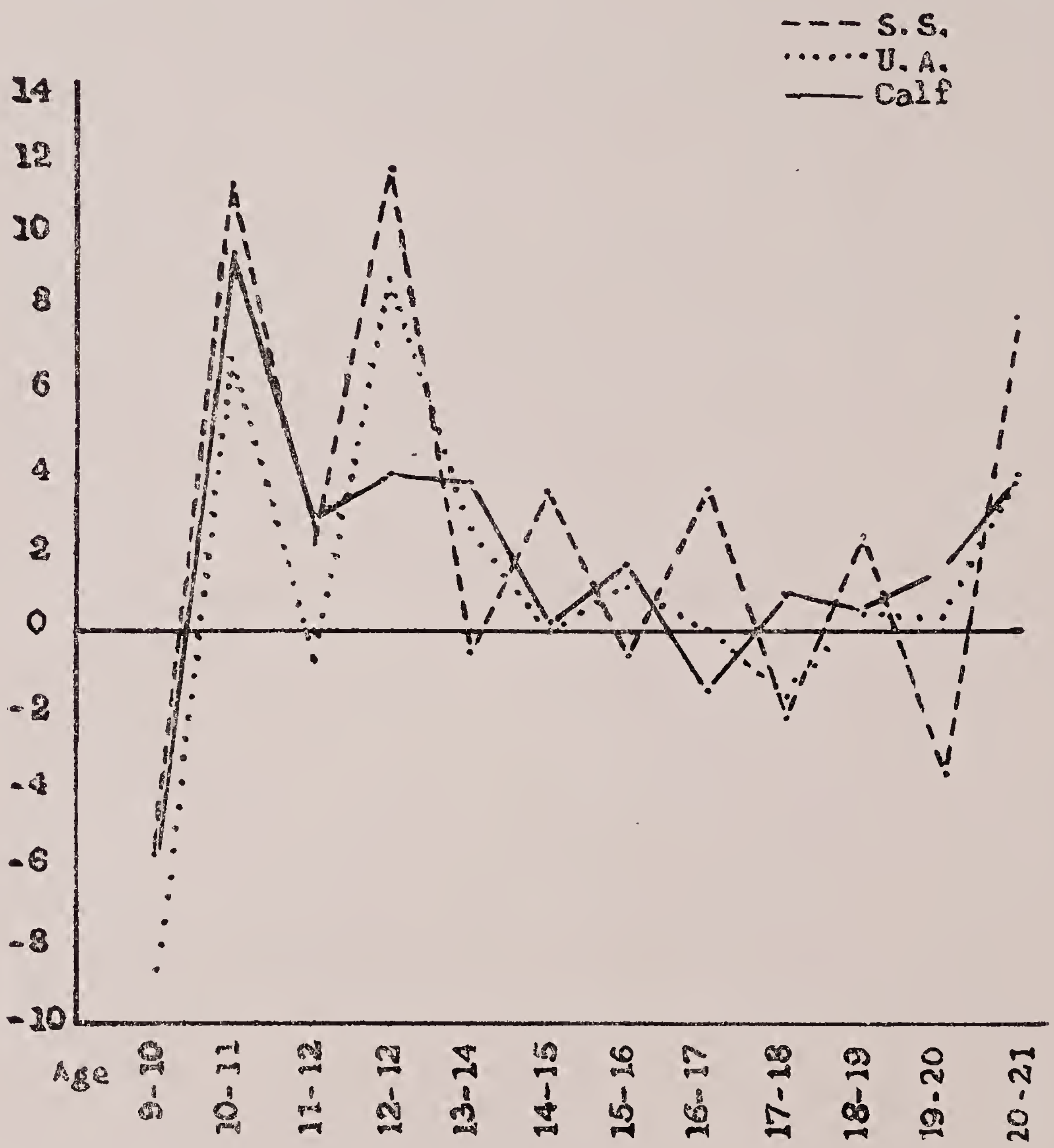


Fig. 28. Velocity curves for fat (log transforms) at three sites, superimposed.

Skinfold and other characters

Weight : fat— The means of the log transforms of the weight and of the subcutaneous fat in the three regions are plotted against each other in Figure 30. The lines are drawn by eye estimation, as has been done by Hiernaux (1968). The slope of the line for the subscapular fat is more slanting at the beginning and bends towards a steeper rise at the later stage. In other words, the rate of increase in weight and that in fat in this region follow a similar course at the beginning up to the weight group of 1.53 (log) after which the rate of increase in fat is more pronounced than that in weight.

The line for the upper arm fat is slanting till the weight measures 1.61 in log value. After this point the fat remains constant when the increase in weight continues. Compared to the sunscapular fat, the increase in upper arm fat is less acute all along.

The calf fat, on the other hand, shows a more steady condition. The line continues to run in the same direction all along. The calf fat line is nearly parallel to the upper arm fat line till the weight group of 1.61. After this the calf fat continues to grow while the arm fat remains stationary and the subscapular fat grows more intensely.

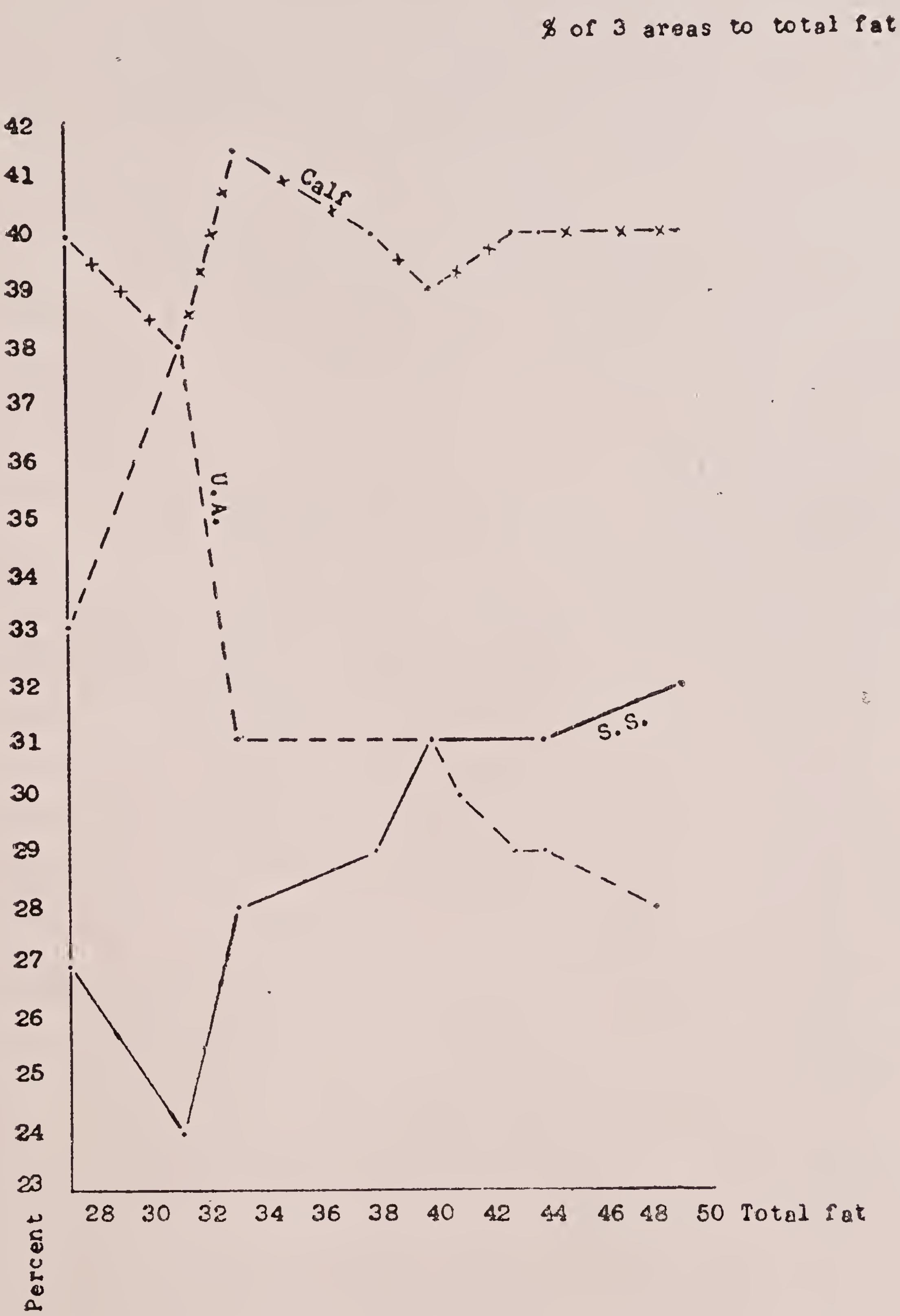


Fig. 29. Percentage distribution for fat (mm) at three sites in relation to total fat (mm).

Stature : fat— The log mean values for skinfold of the three regions,—calf, subscapular and upper arm—have been plotted in F gure 31 against stature groups to determine the relationship between the two. the figure will also give an idea of the relationship in the growth process in the fat of the three regions mentioned. It will be seen that of the three regions, the deposit of fat in the upper arm bears an almost simple linear relationship with the growth of the stature, though there is a very slight bend in the earlier part of the line. The slope indicates that

as stature increases the fat on the upper arm also increases likewise throughout the entire span. As indicated in the trend lines, the deposit of fat in each of the calf and the subscapulor regions consists of two portions. In each case, the earlier segments which are longer are at an angle with the latter portions which are shorter. This indicates unequal rate of deposit in fat for these two regions. The angle of the bend shows that the rate of growth for the subscapular fat after the

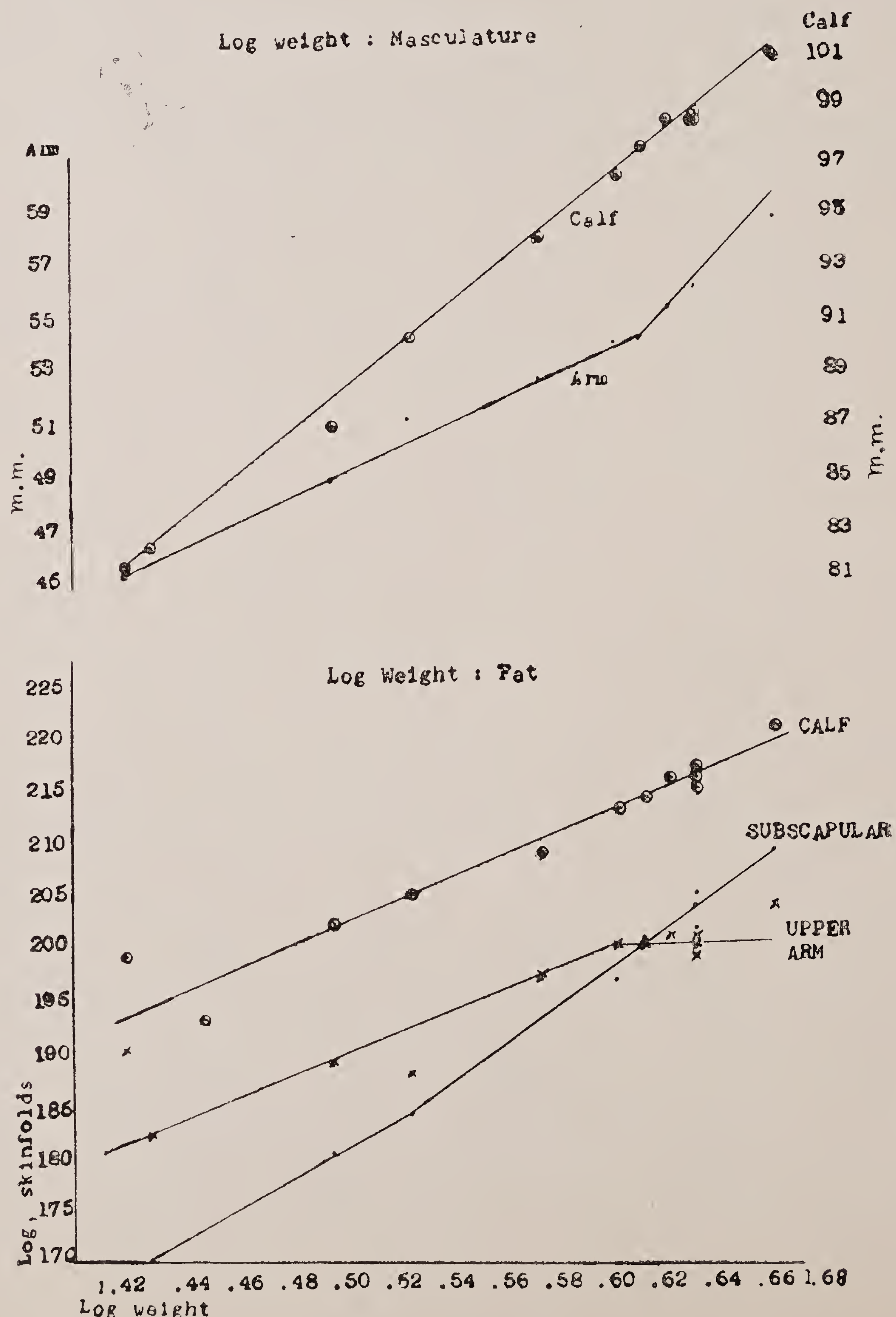


Fig. 30. Regression lines for log weight and log fat of three sites. Top figure shows log weight and musculature at two sites.

152 cm stature group is faster than it is for the earlier part. Similarly, the segment for the calf after 150 cm stature group indicates faster deposit of fat in this portion than that in the earlier one.

Girth : fat— As the girths and skinfold measurements of the upper arm and the calf have been taken at the same areas these two areas are taken into account. The girth of the chest does not correspond to the region where the subscapular skinfold is taken. Consequently, these two measurements are of no avail in this discussion.

The log transforms of the upper arm skinfolds are plotted against the upper arm girth in Figure 32. The relationship-line of these two measurements runs obliquely all along, indicating a constant relationship of the increment of one with that of the other. In other words, the girth of the arm is dependent on the amount of subcutaneous fat deposit on the arm as the age progresses.

The log transforms of the calf plotted against the girth of the calf in Figure 32 shows a somewhat different picture than the arm. The line bends at the point where the fat reads 205 (log units) and the age records 12 years. This bend depicts that the calf girth increases at a slower rate than the calf fat from the age of 12 years and that prior to this age the increase in these two measurements is at the same pace.

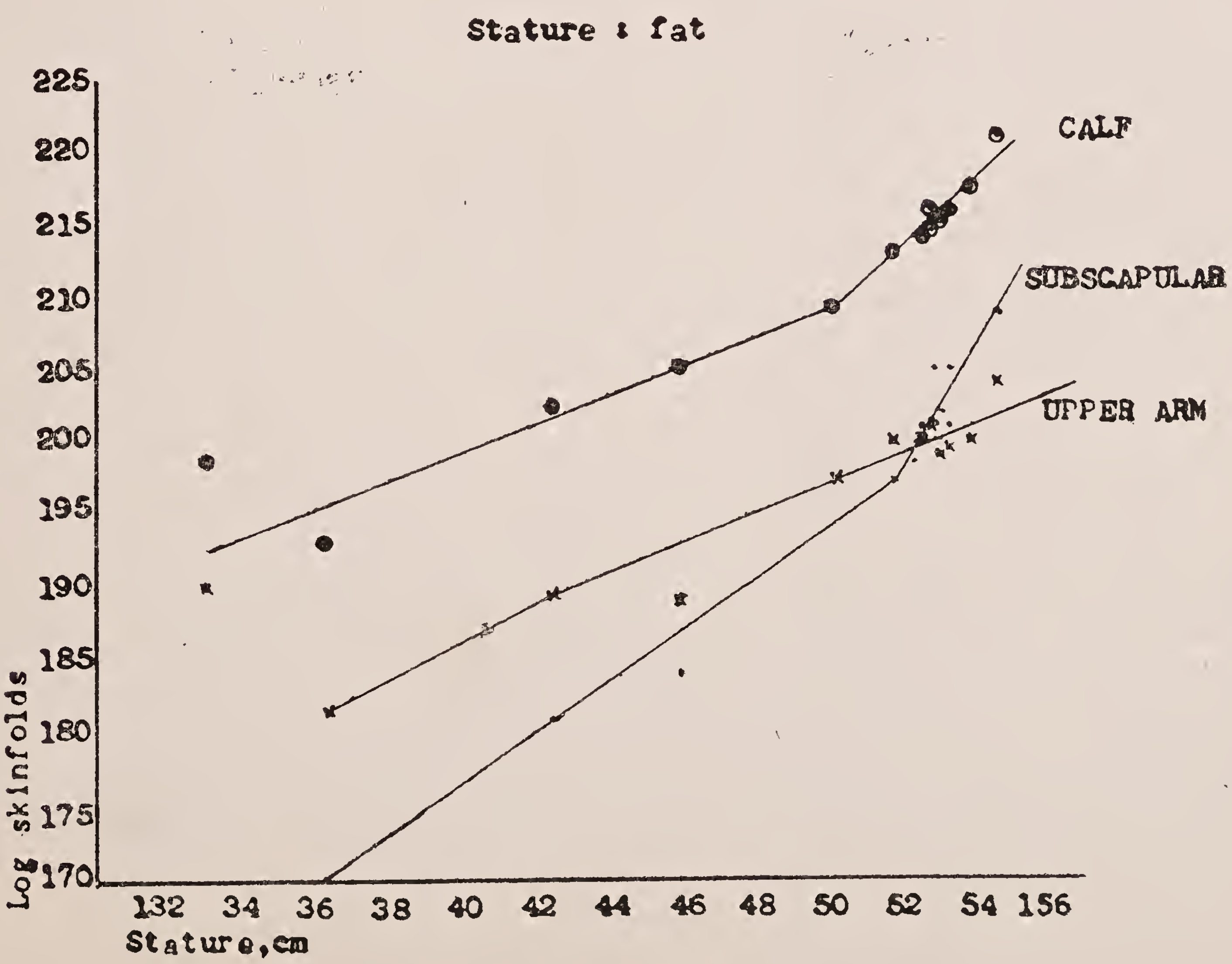
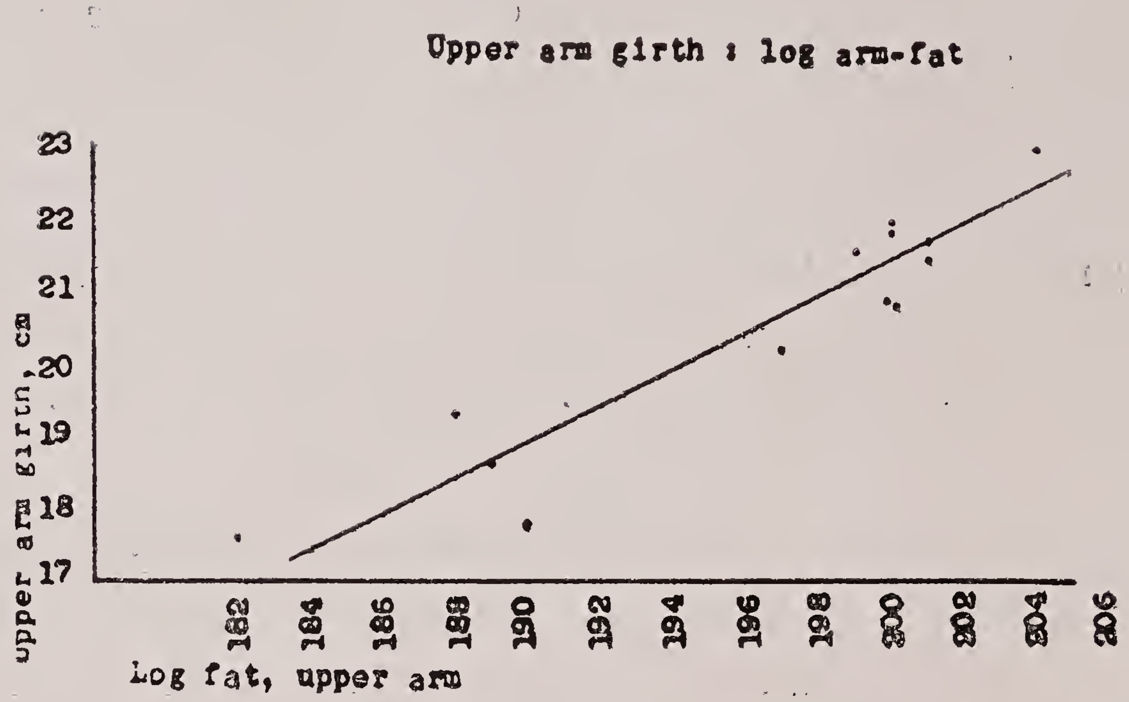


Fig. 31. Regression line for stature and log fat at three sites.



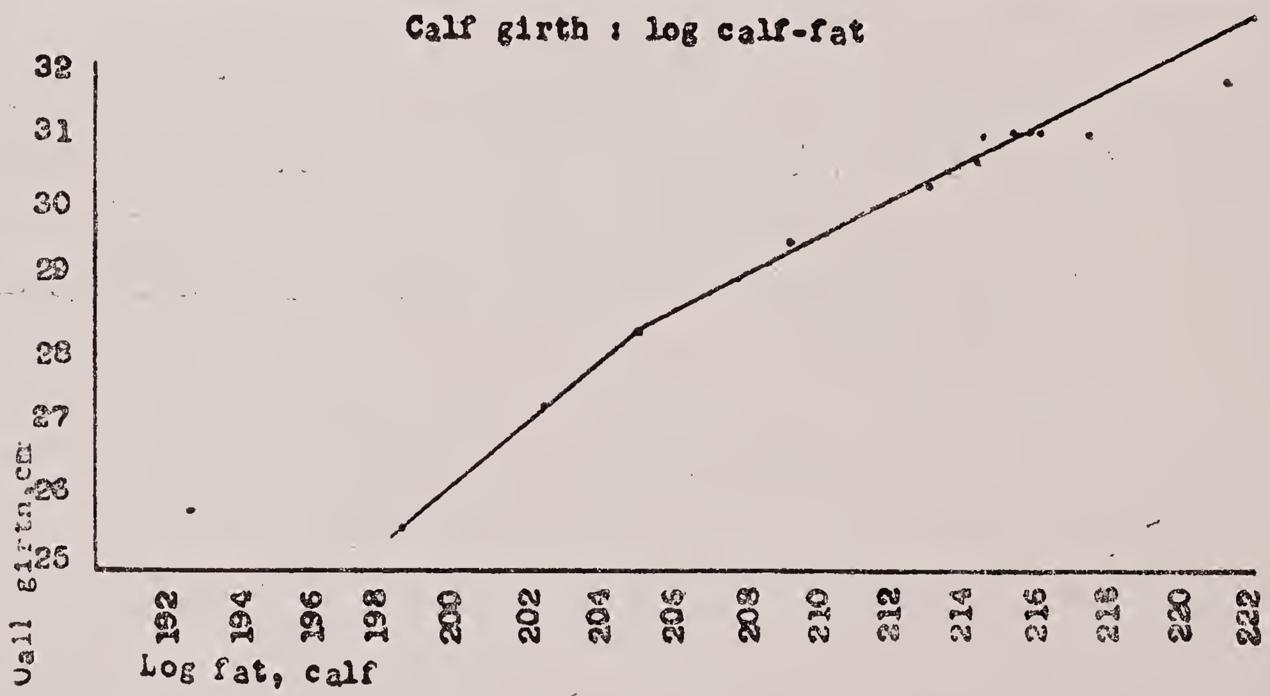


Fig. 32. Regression line for upper arm girth and upper arm fat (log); and for calf girth and calf fat (log).

Fat and musculature

The musculature of the upper arm and lower leg has been caclulated from the girth and skinfold measurement of the respective areas (Brozek, 1963). The musculature here includes muscle and bone. The calculated diameter indicates the physical build of the girls of the age groups studied in the present sample.

Table XXII gives the calculated diameters, musculature and fat (skinfold—2 mm., i.e., thickness of two layers of skin) of the upper arm and calf.

Musculature : age— The derived values of the musculature of the upper arm and calf have been plotted against the age in Figure 34. The calf muscle shows fast rise from 9 to 14 years,

Table XXII : Mean diameter, musculature, and fat of upper arm and calf according to age

Age in years mid-point	Diameter		Musculature (diameter-skinfold)		Fat (skinfold—2 mm)	
	Upper arm (mm)	Calf (mm)	Upper arm (mm)	Calf (mm)	Upper arm (mm)	Calf (mm)
9	56.6	81.5	45.05	69.80	9.55	9.70
10	56.0	82.2	46.85	71.30	7.15	8.90
11	59.1	86.9	48.65	73.40	8.45	11.50
12	61.3	90.2	51.10	76.15	8.20	12.04
13	64.3	94.0	52.60	78.95	09.70	13.05
14	66.4	96.3	54.00	80.75	10.40	13.55
15	66.6	97.5	54.10	81.55	10.50	13.95
16	68.1	98.5	55.41	80.85	10.69	15.65
17	68.6	98.4	56.05	81.50	10.55	14.90
18	68.5	98.8	55.75	81.10	10.75	15.70
19	68.9	98.5	56.25	81.10	10.65	15.40
20	69.7	98.6	57.15	80.80	10.55	15.80
20+	72.7	100.9	58.70	81.10	12.00	17.80

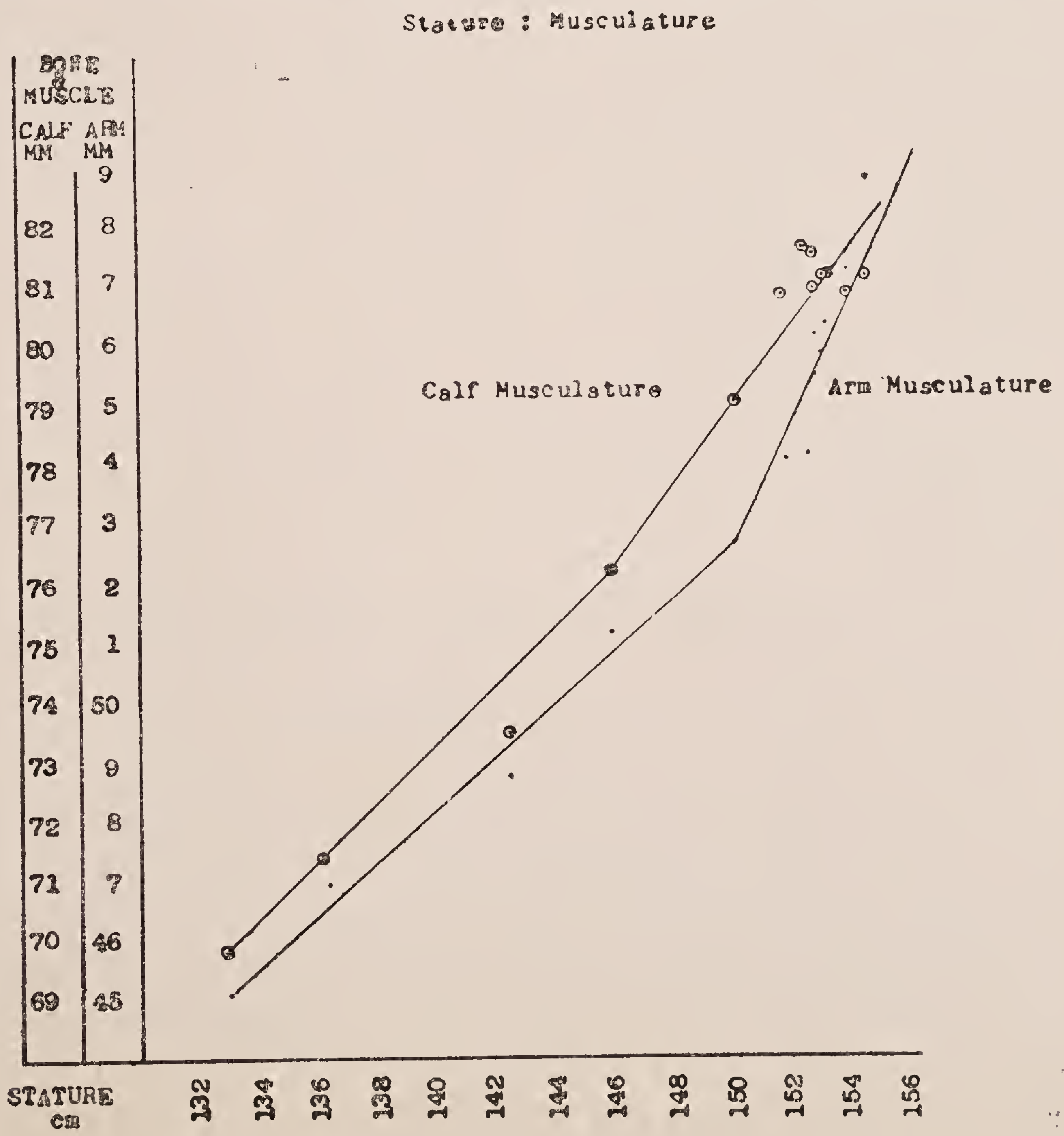


Fig. 33. Regression line for stature and musculature.

having acceleration from 11 to 12 years of age after which it tends to settle down. While the arm muscles show increase even after 14 to a considerable extent though the acceleration takes place between 11 and 12 years of age.

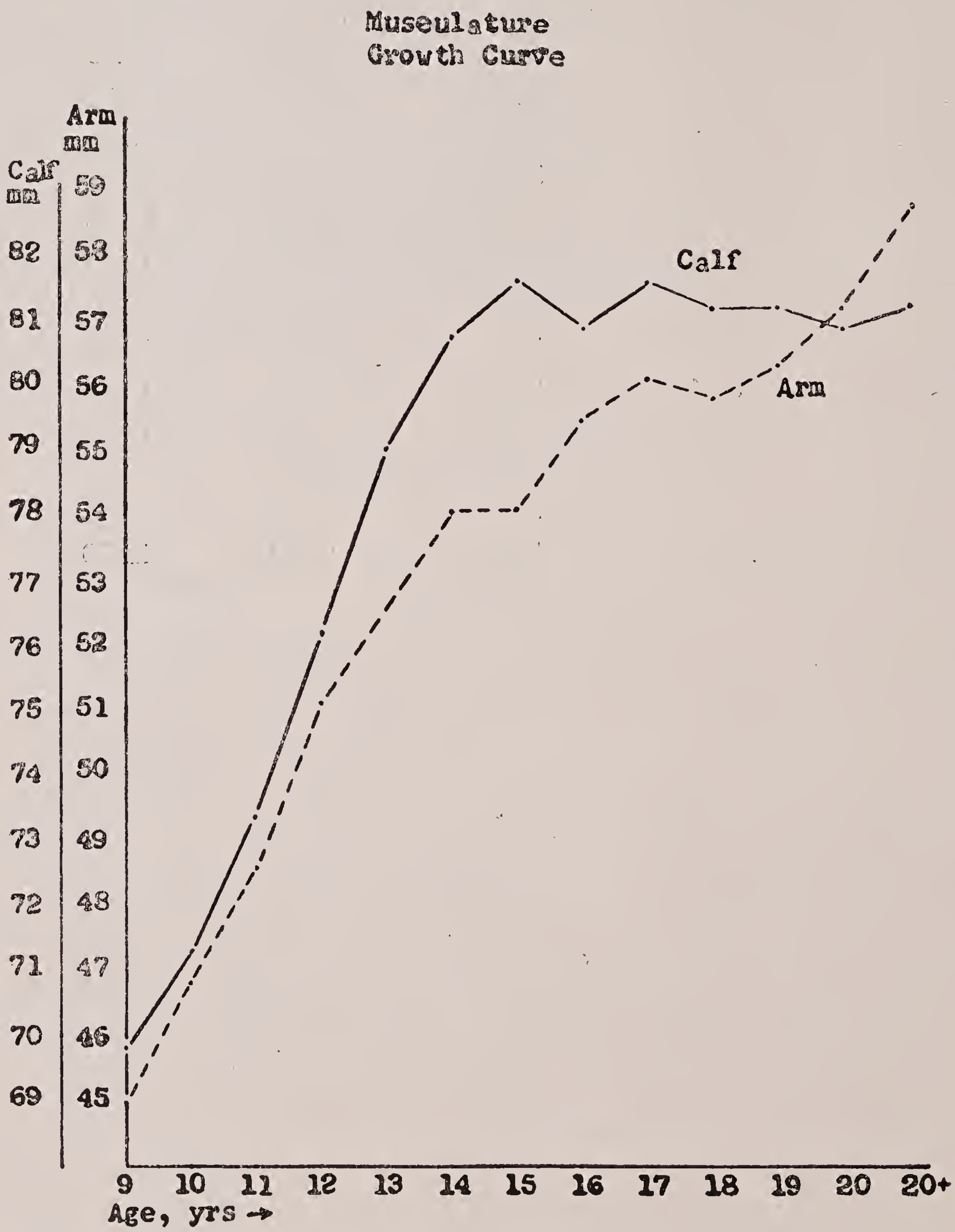


Fig. 34. Growth curve for arm and calf musculature.

Musculature : stature— The mean values for the musculature of the upper arm and those of calf have been plotted against stature in Figure 33 in a regression line to show the relationship between the two dimensions. It will be seen that the musculature at both the sites increases as the stature increases. Moreover, both the latter parts of the regression lines show steeper rise than the earlier parts. This denotes a somewhat quicker rate of development in musculature as compared to stature. In this respect, as the angles of the two segments of the 'calf line' and the 'arm line' will show, the rate of development of the arm musculature is slightly faster in the latter half of the segments than that of the calf musculature.

Musculature : weight— The relationship between the weight and the musculature of calf and arm respectively is shown in Figure 30. It will be seen from the slope of the two lines that in relation to weight the calf musculature develops much faster than the arm musculature. The distribution of calf musculature in relation to weight can be covered with a single straight line. Whereas that of arm musculature constitutes two trend lines with a very wide angle. This means that while calf musculature increases at a more or less even rate throughout the 'weight series' the arm musculature increases at a faster rate in the latter part of the weight series than in the earlier part.

DENTITION

The teeth of the Bengalee girls in the present samples have been observed to determine the age of eruption of the permanent set of teeth. The start and completion of eruption of the II molars were nearly covered by the range of age groups considered in the study. The III molars, considered as a set, did not show completed eruption. The eruption of the I molars started before 9 years and was complete by about 10 years of age. The percentile of occurrence of the I and the III molars, the premolars and the canines has been calculated agewise. Moreover, for the purpose of this study, the eruption of the III molars is felt to be of the greatest importance. The completion of the whole set of the III molars indicates the near-completion of growth. Keeping this in view the sequence of the eruption of the teeth is discussed in the direction from back to front.

III molars

Table XXIII shows the percentage distribution of the occurrence of the III molars according to age. They were absent below 14 years age; as such, Table shows 14 to 21 and 21+ years. The age group 20+ years, as already discussed under other headings, was divided into two age groups, 21 and 21+, as the set of the III molars showed eruption between 21 and 21+ years in a large number of cases. By 24 years 71.43 per cent of the cases showed complete eruption of the III molars. Maxillary and mandibular teeth have not been dealt with separately.

Logically it is expected that persons having three III molars would be greater in number than those with two and less than those having four. But it can be noted from Table XXIII that the percentage of cases with 3 teeth erupted is almost in every age group lower than that with 2 teeth erupted. The explanation for this anomalous picture probably is this—the third and the fourth teeth erupt in quick succession so that the persons in 3-teeth stage are fewer in number than those in 2-teeth stage, while the time taken between the eruption of first and second III molars is relatively longer.

The eruption of the III molar in the 4 stages has been plotted percentage-wise against the different age groups in Figure 35. The line for all-erupted III molars rises from 15 years to 17 years at a slow pace, from 17 to 21 a little greater and after 21 steeply. By 21+ more than 71 per cent of the cases show complete eruption. At 20 years of age nearly one-third of the number of girls shows 4-teeth completion, one-third with none (not shown in Figure 35) and the remaining one-third shows the intermediate stages.

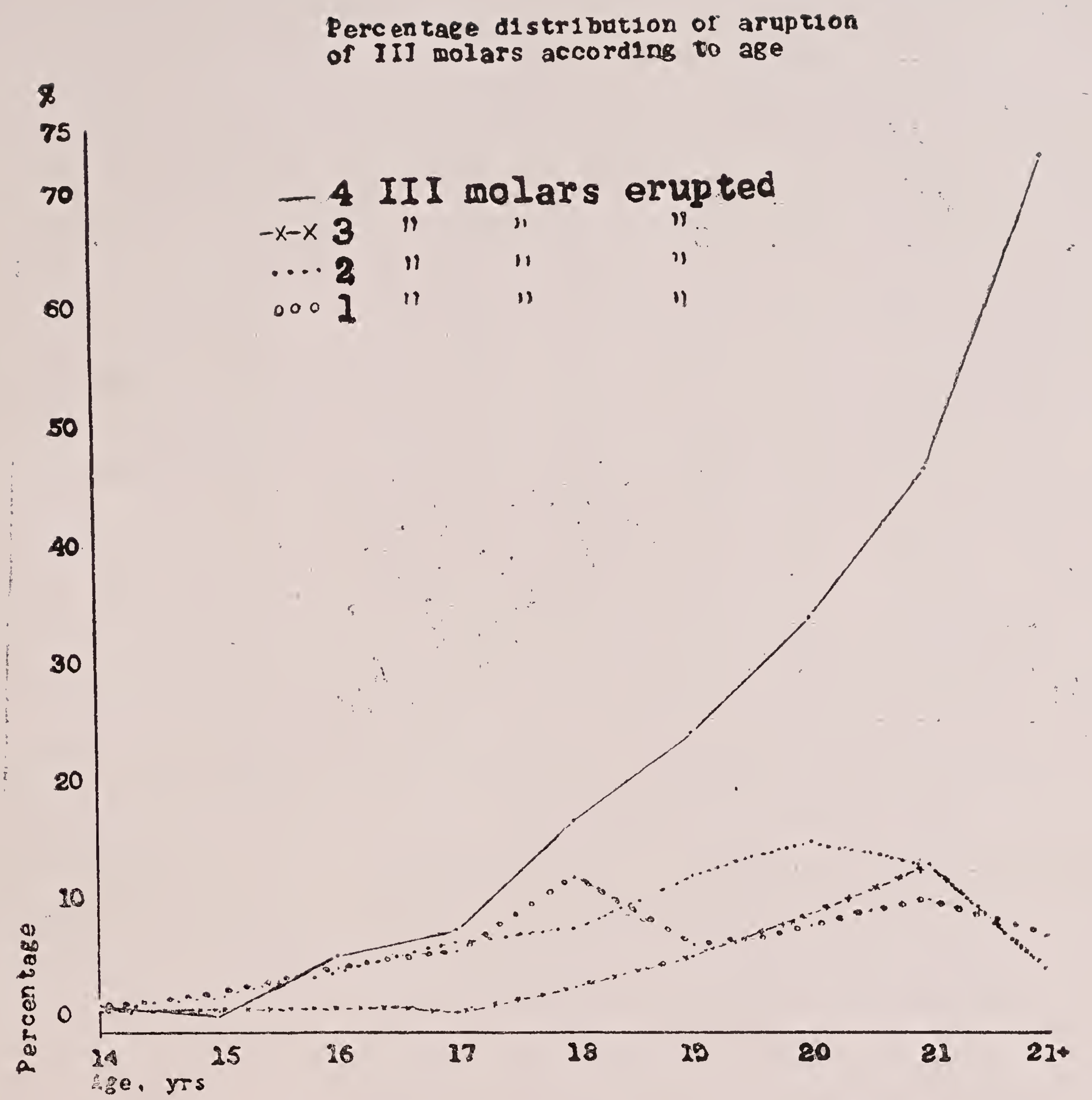


Fig. 35. Percentage distribution for eruption of all III molars according to age.

It may be noted that as the acceleration of growth in bones (stature and bi-acromial diameters) stops and the increase in weight slows down at the age of 14 or 15 years, the eruption of the III molars starts. A similar condition has been noted by Count (1943) where he states that 'growth is actually braked to a stop—at about III molar time'. In the present study '14 years' may be taken as the particular period of emergence of the III molars though the 4-teeth stage is achieved later. No occurrence of the III molar was noticed earlier than 14 years in the present sample. Young (1964) found in the Canadians the completion of the eruption of all the teeth within 21 years of age, the range of age for theeruption of both maxillary and mandibular III molars being 16 to 21 years.

Steggarda *et al* (1929) studied American girls of mainly British origin from Smith College. Though the age groups are comparable to those of the present sample the number of cases in most groups in Steggarda's series is very small. However, the second largest group in Steggarda's study, i.e., 20 years (n = 23), shows the full set of teeth in 21.74% of cases, whereas for the Bengalees

Table XXIII : Number of cases and the percentage distribution of occurrence of III molars according to age.

Age in years mid-point	Number	Numbers of erupted III molars									
		Four		Three		Two		One		None	
		No.	%	No.	%	No.	%	No.	%	No.	%
14	215	2	.95	1	.47	1	.47	2	.95	209	97.18
15	215	8	.37	1	.46	4	1.86	4	1.86	198	95.45
16	290	15	5.17	2	.68	10	3.44	11	3.79	252	86.92
17	236	16	6.94	0	0	15	6.52	13	5.34	192	81.20
18	263	41	15.58	6	2.28	19	7.22	30	11.41	167	63.51
19	226	53	23.45	11	4.86	26	11.50	11	4.86	125	55.33
20	163	54	33.13	13	7.97	23	14.11	12	7.37	61	37.42
21	88	39	45.46	9	10.22	9	10.22	8	9.09	23	25.01
21+	35	25	71.43	1	2.86	1	2.86	2	5.71	6	17.14

in the same age group it is 33.13%. So nearly one-fourth of the number of the Smith College girls and one-third of the number of the Bengalee girls at twenty years of age show all the III molars erupted.

II molars

Erupted II molars were observed from 8.5 years of age onwards up to 14 years of age yielding the mean age for all the four II molars as 12.72 ± 0.05 years (S.D. = 1.22 years). The percentage distribution of the eruption of one to four II molars and their non-eruption in the various age groups are given in Table XXIV.

As in the case of the III molar, here also the 3-teeth stage almost always numbers least, except at 9 and 14 years—the two terminal age groups. This shows fewer cases of 3-teeth stage, or in other words, like the III molars, the II molars also have qucik succession from 3-teeth to 4-teeth stage.

The close association of the growth in stature and the eruption of II molar is remarkable. The acceleration in the increment in stature goes hand in hand with the acceleration in eruption of the II molars. As the stature decelerates from the age of 13, nearly 85% of the girls show completed eruption of the II molars as a set. At the age of 16 years 100% of the girls have all their II molars and the stature tends to stabilize.

Table XXIV : Number and percentage distribution of the cases with erupted II molars in different age groups

Age in years mid-point	Number	Four No.	Four %	Three No.	Three %	Two No.	Two %	One No.	One %	None No.	None %
9	34	2	5.88	1	2.94	0	0	2	5.88	29	85.30
10	193	32	16.58	3	1.55	14	7.25	4	2.07	140	72.65
11	198	82	41.41	4	2.02	22	11.11	9	4.54	81	40.92
12	181	117	64.64	1	.55	15	8.32	6	3.31	42	23.18
13	199	147	87.43	2	1.00	9	4.52	4	2.01	10	5.04
14	215	210	97.67	2	.93	1	.47	0	0	2	.93
15	215	215	100	0	0	0	0	0	0	0	0

The bi-acromial diameter also shows much similarity with the II molars in growth pattern. From 15 to 16 years of age the curve for bi-acromial diameter hardly rises. And the same is the case with the II molar. Both seem to settle down at this stage as does the stature. The somewhat upward trend of the bi-acromial and stature lines at the later age groups is not an unlikely variation in a cross-section study.

The weight line runs nearly parallel to the II molar line up to about 11 years of age although the two lines are not as much close as the II molar and the stature lines. But for a slight dent at the age of 12 years the course of the weight-line is almost similar to the II molar line. The weight, as expected, shows stabilisation at a later age.

Crampton (1908) demonstrated a correlation between dental development and stature and weight. Spier (1918) proved close relation between the stature and tooth eruption at all ages from 7 to 13 years in boys. According to Tanner (1962), the tooth eruption is closely related to growth at adolescence. Meredith (1959) found the peak velocity in stature correlated with the eruption of the I and II molars. Though Nanda (1960) found no correlation between the menarcheal age and the completion of the II molars, Eveleth (1966) points to a strong indication of menarche affecting the tooth eruption amongest the American children living in Brazil.

The present study corroborates the views of the abovementioned authors. Stature and menarcheal age, as already shown, are closely connected with the eruption of the II molars. The average age at menarche (12.48 years) and the average age of completion of the II molars (12.72 years) are almost simultaneous. We can also look at the coincidence from a percentage point of view : the percentage of girls who had menarche rises slowly at the beginning, i.e., between 9 and 11 years of age and then very fast between 11 and 13 years. Ultimately, 100 per cent is reached at the age of 17 for this series while the II molars are completed (100 per cent) by 16 years of age.

At 16 years 98.97 per cent of girls have had menarche simultaneously with the completion of the II molars.

Dr. Walter Channing (in Spier 1918) found the mean and standard deviation in age of eruption of the II molars among the Boston girls to be 12.8 years and 1.6 years respectively. These figures tally with those of the present series. The mean age for eruption of the II molars in Puerto Rican girls as recorded by Spier (1918) is 11.8 ± 0.9 years which is somewhat earlier than that in the Bengalee girls.

Young (1964) records the average age as 12 years for all the maxillary and mandibular erupted II molars in the Canadian girls, the range being 11 to 13 and 10 to 13 years respectively. The calculated combined range for the present sample is 11.50 to 13.94 years which is later than this. Reid and Grainger (1955) also recorded the average age of eruption of these teeth as 12 years amongst 1144 school children from Burlington, Ontario.

Clements *et al* (1953) show the mean age of eruption of maxillary and mandibular II molars—11.66 years as calculated by the present investigator—for Birmingham girls which is nearly a year in advance of the present sample. Klein *et al* (1937) give the mean age of eruption of the II molars as 12.53 years which is similar to that for the Bengalee girls. In Shourie's study (1964) the mean age of eruption of the II molars of South Indian vegetarian girls is 11.72 years (calculated by the present investigator), which is just one year in advince of that for the Bengalee girls.

Summing up the foregoing comparisons, it is clear that like the Boston girls the Bengalee girls also achieve the 28-teeth stage later than the Canadian, British or Puerto Rican girls. But the Bengalee girls fall within one standard deviation of the mean age of eruption of the II molars given for these studies.

I molar

All the I molars erupted before 8.5 years in this sample. This finding is in accord with Saito's study (1936) on the Japanese girls and Young's study (1964) on Whites.

II premolar

By 14 years of age almost all the girls of the present series have a set of 24 teeth. Sporadic occurrence of milk teeth in the higher age groups will be discussed later. The occurrence of the II premolars, both maxillary and mandibular combined, is shown in percentage distribution in the various age groups concerned in Table XXV. The mean age of eruption of all the II premolars is calculated to be 12.54 ± .05 years with a standard deviation of 1.32 years.
1.32 years.

Compared to this, Shourie's data show the percentages of girls who have all the II premolar teeth erupted in Table XXVI. These percentages were calculated from the table of figures in Shourie's paper (p. 109).

Table XXV : Number and percentage distribution of cases with erupted II premolars in Bengalee girls according to age

Age in years mid-point	Number	No. of erupted II premolars: Four No.	Four %	Three No.	Three %	Two No.	Two %	One No.	One %	None No.	None %
9	34	4	11.76	3	8.82	1	2.94	1	2.94	25	73.53
10	193	61	31.61	4	4.67	22	11.39	3	5.95	98	50.77
11	198	96	48.48	9	4.55	34	17.17	8	4.04	51	25.76
12	181	138	76.24	10	5.52	15	8.30	1	.55	17	9.39
13	199	184	92.46	3	1.51	9	4.52	0	0	3	1.51
14	215	210	97.68	0	0	5	2.32	0	0	0	0
15	215	215	100.00	0	0	0	0	0	0	0	0

Shourie's data were also collected from a rice-eating area (Madras, South India) and his subjects too were city girls. The sample size is 474 with age varying between 6 and 21 years. By 15 years of age, cent per cent occurrence of the II premolars was found.

Table XXVI : Shourie's series showing percentage distribution of cases with all II premolars according to age

Age in years mid-point	Total number	Percent having all II premolars
9	28	5.5
10	34	21.5
11	54	48.75
12	50	83.50
13	50	95.00
14	41	97.75

The present data are very similar to Shourie's with regard to the completion of the II premolars. The similarity in the emergence of these teeth in all the girls from 9 to 15 years is worth noting.

Young (1964) gives the approximate age for the eruption of the II premolars as 11 years with a range from 9 to 12 years. The present series shows a longer span up to 14 years, though by 12 years of age 76·24% of girls have all the four II premolars. The lower limit of the span is lacking in this series as the lowest age group, 9 years (8.5 to 9.5 years), already shows 11.76% of girls having all the four premolars in their mouth.

According to Clements *et al* (1953), the mean age for the British girls for the emergence of the II premolars is 11.06 years ± 1.84 years and 11.64 years ± 1.82 years for upper and lower jaws respectively. The calculated mean for both, upper and lower inclusive, is 11.35 years, S. D. 1.83 years. In the present series the mean age is higher than Clements' finding.

Channing's (1908) series of Boston girls gives the mean age of eruption of all the II premolars as 11.2 ± 2.9 years which also is lower than that of the present series (12.54 ± 1.32 years). But the present sample falls within one standard deviation of Channing's series.

The lowest group in the present series has the whole set of II premolars in 11.76% of cases and as such the higher mean may be due to the lack of data from the age below 8½ years. This may explain the higher mean age of the eruption of all the II premolars than in the other studies compared with.

I premolars

The eruption of all the I premolars (both maxillary and mandibular) of the Bengalee girls of the present sample is given in precentage for each age group prior to the cent percent occurrence in Table XXVII. The mean age of eruption of all the I premolars is 11.74 years ± .04 years, S.D., 1.08 years. This mean age is 0.80 years less than the mean age of eruption of the II premolars.

Shourie's data on South Indian girls give the mean age of eruption of all the I premolars as 10.31 years (calculated from means for each tooth in Shourie's series). This age is lower than that for the present series. The precentage distribution of Shourie's sample of girls shows the following calculated values of all the 4 teeth in each age group concerned.

Table XXVII : Number and percentage of distribution of cases with erupted I premolars accordning to age

Age in years mid-point	Number	Four No.	Four %	Three No.	Three %	Two No.	Two %	One No.	One %	None No.	None %
9	34	10	29.41	2	5.88	2	5.88	0	0	20	58.82
10	193	82	42.48	28	14.51	32	16.58	8	4.17	43	22.05
11	198	165	83.33	14	7.07	12	6.06	2	1.01	5	2.53
12	181	172	95.03	4	2.21	1	.55	1	.55	3	1.66
13	199	194	97.48	2	1.01	2	1.01	0	0	1	.50

Age in years	Percent having four I premolars
9	16.75
10	41.75
11	74.00
12	98.00

Shourie's data and the present series show close similarity to each other.

The average age of eruption of the complete set of the I premolars of the White population given by Young (1964) is 10 years, the range being 9 to 12 years which is earlier than those for the present series. Clements *et al* (1953) give the average age for Birmingham girls as 10.16 years which also is earlier than the age for the present sample.

The age of eruption of both upper and lower premolars amongst the U.S.A. girls, studied at Denver, Michigan, Cleveland and New York by Steggarda and Hill (1942), Hellman (1943), Fulton and Price (1954) and Nanda (1960) respectively comes to 10.5 years on an average and is 1.25 years earlier than that for the present series.

As has been argued for the higher mean age of the eruption of the II premolars in the present series, the same reason is found to be common for the I premolars also. By 9 years of age 29.41% of girls have already all the premolars present in their mouth ; hence the higher mean may be expected.

Canine

The canine teeth of the Bengalee girls were found in complete eruption by 13 years of age. Occasional absence of this tooth is found up to the age of 15 years which may be considered as abnormal and will be dealt with later.

The mean age, standard deviation and standard error of mean for eruption of all four canines are 11.72 years, 1.13 years and .04 years respectively for the girls of the present sample. Table XXVIII shows the percentage distribution of eruption of canines in the age groups between 9 and 13 years.

Table XXVIII : Number and percentage distribution of cases with erupted canines according to age

Age in years mid-point	Number	No. of erupted canines: Four No.	%	Three No.	%	Two No.	%	One No.	%	None No.	%
9	34	12	32.32	4	11.76	4	11.76	2	5.88	12	32.3
10	193	84	43.52	37	19.17	50	25.91	11	5.70	11	5.7
11	198	176	88.88	10	5.56	12	6.06	0	0	0	0
12	181	177	97.80	2	1.10	2	1.10	0	0	0	0
13	199	197	99.00	1	.50	1	.50	0	0	0	0

As can be noted from Table XXVIII, at least two canines have erupted in all the girls by 11 years of age and except in two cases all the four teeth have erupted by 13 years of age. At 9 years the girls having 4 teeth and those having none are of equal number. Compared to this series, Shourie's data show a very close agreement. The percentage distribution of Shourie"s series and of the present series for eruption of all canines is given in Table XXIX.

Table XXIX : Percentage distribution of eruption of all canines in Shourie's and in the present study according to age

Age in years mid-point	% Shourie's series	% Present series
9	18 75	32.32
10	43.25	43.52
11	76.25	88.88
12	96.00	97.80

The girls of Shourie's series show the mean age of eruption of all canines (calculated from the table on p. 117) as 10.83 years which is nearly a year earlier than that for the present sample.

Klein *et al* (1937) and Channing *et al* (1908) give the average age for canines as 11.42 and 11.3 ± 1.0 years respectively for the American White girls. These means are similar to that for the Bengalee girls. Clements *et al* (1953) give the mean age of eruption of these teeth for the British girls, to be 10.04 ± 1.12 years. This mean is again earlier than that for the girls in the present sample.

Persistence of milk teeth

The milk teeth were identified by their colour, size and features. The milk tooth is whiter, less lustrous, narrower in width and has lower crown than the corresponding tooth of the permanent set. Milk teeth may be identified also by their position, the milk molars are situated next to the canines, i.e., in place of the future premolars.

In considering the persistence of the milk teeth observation has been made on girls beyond 13 years of age, when milk teeth are not generally expected to be present in the mouth. In addition to this direct observation, the girls found to possess milk teeth were also questioned as to whether they were aware of this abnormality. In all cases where the milk teeth were present they answered in the affirmative.

In the whole series all the lateral milk incisors were already replaced by the permanent ones.

Table XXX shows the presence of any milk tooth, upper or lower, left or right, in the girls of 14 years and above age groups in the present sample. The figures indicate the number of teeth

and not of individual. Further the number and percentage of girls having persistent milk teeth in each group are shown in Table XXXI.

Table XXX : Number of persistent milk teeth of different types according to age

			Age in years (mid-point)			
			14	15	16	17
Mesial incisor	Upper	Right	1			
		Left	1			
	Lower	Right		1		
		Left		1		
Canine	Upper	Right	1			1
		Left	1			1
	Lower	Right	1			2
		Left	1			2
I molar	Upper	Right				1
		Left				1
	Lower	Right		1	1	1
		Left		1	1	1
II molar	Upper	Right	2		1	
		Left	3			
	Lower	Right	2		1	
		Left	3		1	

Table XXXI : Number and percentage distribution of girls having persistent milk teeth according to age

Age in years	No.	No. of individuals	Percent showing milk teeth
14	215	7	3.25%
15	215	2	.93%
16	290	3	1.03%
17	236	4	1.69%
Total	956	16	1.67%

The girls having any milk or deciduous tooth do not have the permanent tooth at that site. In other words, two sets were not found side by side in any of these cases (except in one case in a girl belonging to the 14-year age group where both the upper medial incisors of deciduous and permanent sets were found, the former set being anterior to the latter one). Where milk molars were present, the corresponding premolars were absent. No incidence of the persistence of lateral incisors was found in this sample. Girls above the age group of 17 years do not show any incidence of the persisting deciduous teeth.

No comparable data on the persistence of milk teeth are available.

RELATIVE GROWTH

Proportions of one dimension to the other, expressed by indices, have been worked out for the Bengalee girls in the present sample. The indices have been calculated from the means of the various dimensions.

Stature / weight

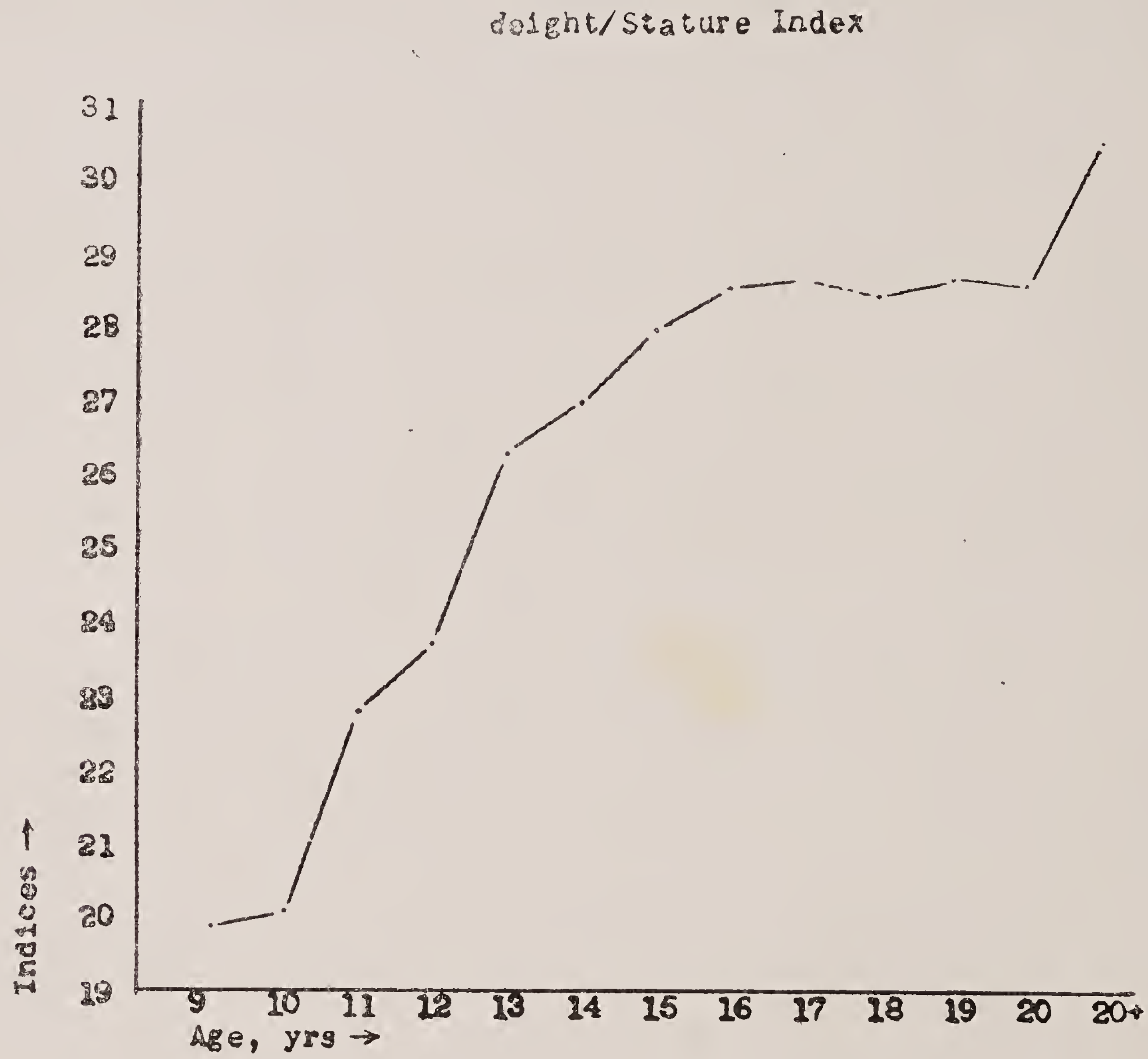
Two indices for stature and weight have been taken into account, viz. $\frac{\text{weight (kg)}}{\text{stature (cm)}} \times 100$ and the $\frac{\text{stature (cm)}}{\sqrt[3]{\text{weight (kg)}}}$, the first one is recommended by Hrdlicka (1925), Steggarda (1940) and Brozek (1956) and the second one by Parrell (1954). According to F.L. Stagg (quoted by Hunt, 1952), the second—the ponderal index—measures the body density rather than attenuation. These two indices are given in Table XXXII according to each age group and are plotted in Figure 36.

Figure 36 shows that the index does not increase perceptibly between 9 and 10, and 11 and 12 years. Increase is most marked between 10 and 11 years and followed by 12 and 13 years. After 13 years of age the increase in weight in proportion to stature is fairly high from one age to another for the next 3 years (i.e., up to 16 years of age). After that it is nearly stationary or both stature and weight increase at the same rate till 20 years of age. After 20 the weight increase is proportionately high.

Table XXXII : Indices of stature and weight according to age, of Bengalee, Baganda, Canadian, Japanese girls

Age in years mid-point	Bengalee		Japanese	Age in years	Baganda
	$\frac{\text{Weight}}{\text{Stature}}$	$\frac{\text{Stature}}{\sqrt[3]{\text{Weight}}}$	$\frac{\text{Weight}}{\text{Stature}}$		$\frac{\text{Weight}}{\text{Stature}}$
9	19.87	44.66	19.67	9.5	21.78
10	20.06	45.20	20.88	10.5	23.25
11	22.76	44.82	22.38	11.4	25.39
12	23.69	44.79	24.46	12.4	27.49
13	26.33	44.04	26.56	13.4	29.50
14	26.90	44.15	28.72	14.5	32.43
15	27.91	43.74	30.60	15.4	33.79
16	28.46	43.42	31.78	16.4	34.24
17	28.55	43.37	32.35	17.4	34.50
18	28.44	43.53	32.74	18.4	34.58
19	28.59	43.44	33.03		
20	28.48	43.68			
20+	30.38	42.86			

The index discussed above describes the proportionate growth of weight in relation to stature as the age progresses. To ascertain the position of weight in relation to stature, log transforms of weight have been plotted against stature in Figure 37. The weight distributes in non-Gaussian form against age, while the distribution of stature is Gaussian, for this reason the



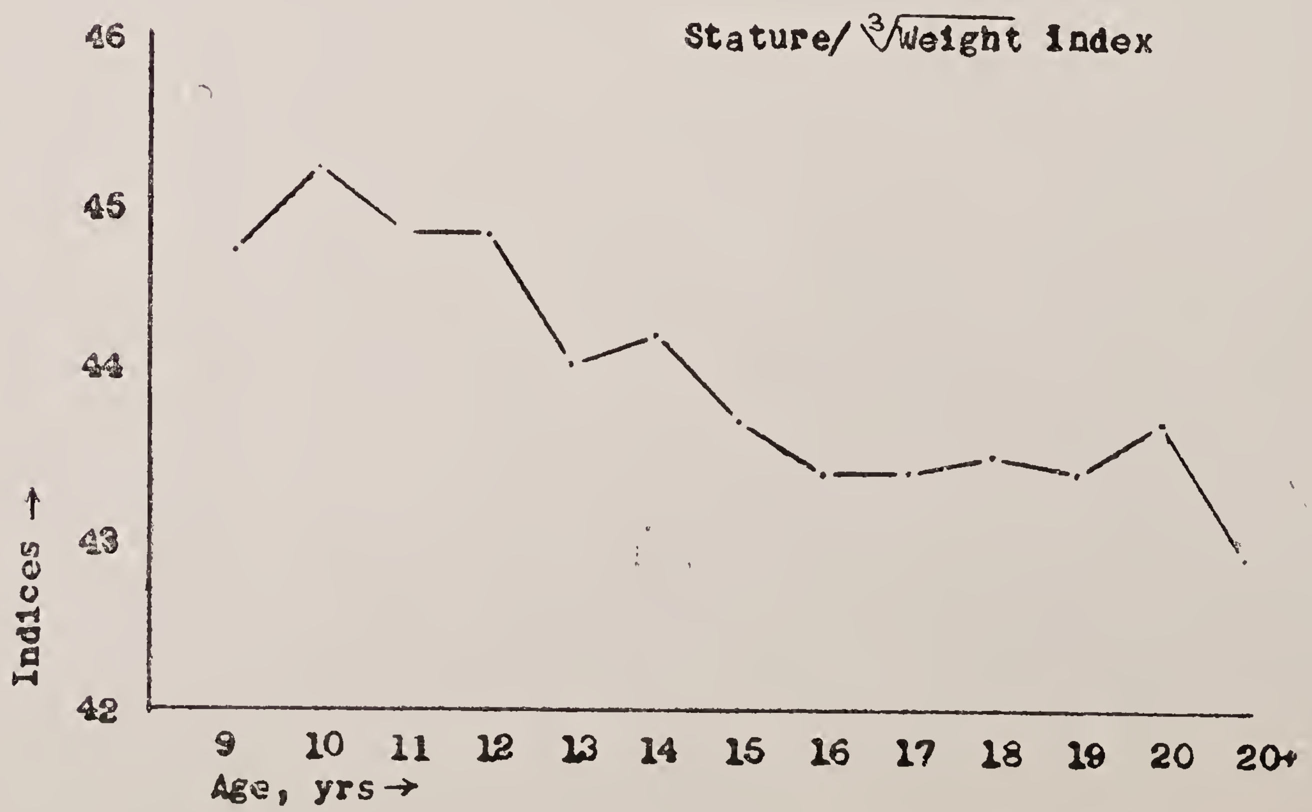


Fig. 36. Age changes in weight/stature and ponderal indices.

log transforms are expected to show a better fit than the direct measures in kilogram as Hiernaux (1962) suggested. Together with the direct plotting of the two variables the regression equation has also been applied and the results plotted in the same Figure (No. 37). The equation used is $\bar{y} = bx + c$, while y is the mean weight in log units, b = .011347, x is the mean value of stature in each age group and c = —.099490. The results obtained from this equation are designated as "theoretical" and the log units plotted directly, as "observed" in the figure. It may be seen from this figure that the regression line runs straight and diagonally, showing a perfect correlation between the weight and the stature. In other words, the weight changes at the same rate as does the stature throughout the span of ages covered in this study. Further, the peak gain in stature at the prepuberal ages coincides with their peak gain in weight after which both the measurements show deceleration. This finding agrees with Krogman's (1948, p. 44) interpretation of height and weight tables of U.S. White children.

The ponderal index plotted in Figure 36 shows a gradual decline in general, except slight rises between 9 and 10, 13 and 14, 17 and 18, and 19 and 20 years of age. This means, if Stagg's interpretation of this index is valid, that the density of the body falls as the age progresses, and more so after 20 years of age.

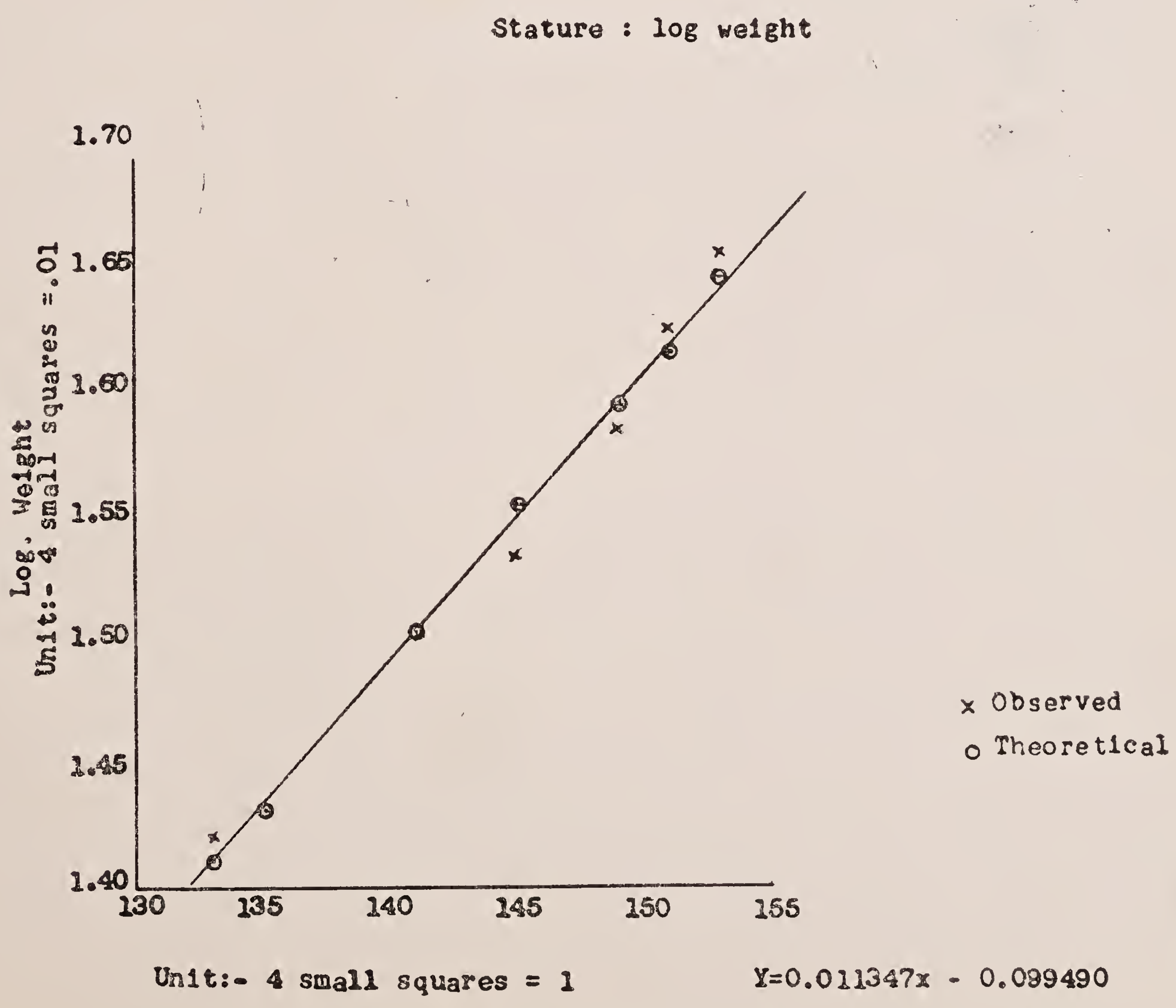


Fig. 37. Regression line for stature and log weight.

Comparisons

The weight/stature index of the Chinese girls was given by Appleton (1925). The data for the nativeborn Japanese girls and for the Baganda girls studied by Greulich (1957) and Burgess and Burgess (1964) respectively have been calculated by the present investigator for the index, and the results are given in Table XXXII for comparison. It is to be noted that the index of the Bengalee girls does not increase as much and as rapidly as for other girls. The Chinese girls have higher indices at the late 'teen' ages than the Bengalee girls.

The Japanese and the Baganda girls have heavier bodies compared to their height all through the ages than the Bengalees. But around the age of sixteen years the ratio between weight and stature tends to settle down in both the Japanese and the Bagandas, as it does in the Bengalees, though the ratio is higher in the two former samples. Unfortunately, no ready data for the ponderal index are accessible from other populations whether of India or of any other country. So it is not possible to make a comparative study on this point.

Stature and other lengths

(1) $\dfrac{\text{Sitting height (cm)}}{\text{Stature (cm)}} \times 100 =$ Sitting height Stature index

(2) $\dfrac{\text{Leg length (cm)}}{\text{Stature (cm)}} \times 100 =$ Leg length Stature index

(3) $\dfrac{\text{Arm length (cm)}}{\text{Stature (cm)}} \times 100 =$ Arm length Stature index

These three indices give the proportion of the trunk, leg and arm in relation to stature expressed in percentage. The trunk in this case includes the head and the neck ; the arm includes the hand, and the leg includes the heel. In Table XXXIII is shown the three indices according to the age groups.

These indices plotted in Figure 38 show that the sitting height in proportion to stature gradually decreases from 9 to 12 years of age. Then there is an oscillation towards a higher sitting height from 13 to 17 years of age. Afte wards the proportion of sitting height and stature is nearly stationary. At the age of 20 years and above the sitting height is 52 per cent and the leg length 48 per cent of the stature. The sitting height of the Bengalee girls is proportionately longer than the leg length at the age of 9 than at the age of 10 years. At 10 years of age, there is a sharp rise in the leg length in proprotion to stature and this proportion is maintained for the rest of the period.

Comparisons

The trend in this relative growth is markedly similar to Shuttleworth's study. But tne diffe-

rence is observed in the age-wise distribution of the values. The lowest value for sitting height/stature amongst the girls in Shuttleworth's study is at 10 years, for the M-G age group 10.5, and at about 14 for the M-G age group 14.5. For the present series the lowest value occurs at 12 years. The ultimate ratio in the former series is between 52.5 and 53.5 while for the present series it is 52, as mentioned before.

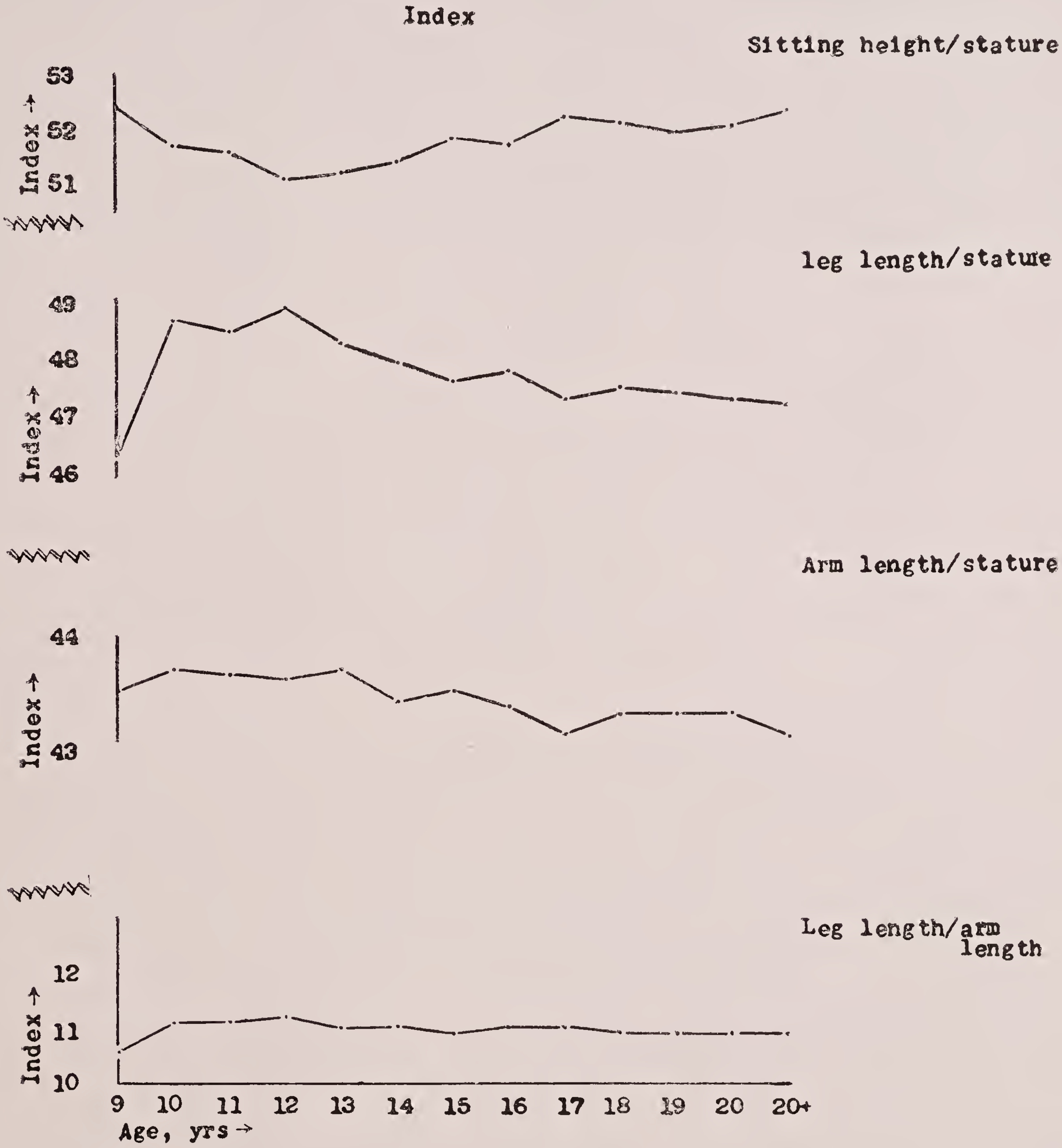


Fig. 38. Age changes in sitting height/stature, leg length/stature, arm length/stature and leg length/arm length indices.

The relationship between the leg length and stature, and the sitting height and stature have been shown in Figure 40. From the lines in this figure the conclusion may be drawn that the increase in stature is contributed by both the increase in sitting height and leg length until the stature reaches 150 cm. After this, however, the contribution of the sitting height to the increment in stature is more than that of the leg length. This is clearly depicted in the figure

where the sitting height line bends to take an upward journey, while the 'leg length line' flattens out.

XXXIII : Indices of sitting height/stature, leg length/stature, arm length/stature, leg length/arm length according to ages

Age in years mid-point	Sitting height / stature	Leg length / stature	Arm length / stature	Leg length / Arm length
9	52.38	46.22	43.47	10.64
10	51.73	48.61	43.67	11.13
11	51.55	48.35	43.63	11.06
12	51.10	48.77	43.64	11.17
13	51.22	48.15	43.68	11.02
14	51.47	47.87	43.43	11.02
15	51.75	47.52	43.47	10.93
16	51.65	47.65	43.36	10.99
17	52.17	47.17	43.07	10.95
18	52.14	47.36	43.34	10.92
19	51.93	47.29	43.29	10.92
20	51.98	47.24	43.27	10.92
20+	52.27	47.09	43.09	10.93

Comparisons

For the leg length/stature relation the sharp rise from 9 to 10 years group is noticed even in Shuttleworth's series for M-G group 10.5 but for the M-G group 14·5 this rise is marked at about the age of 14 years. In this respect the Bengalee girls come close to the M-G age group 10.5 of Shuttleworth. Steggarda (1940) shows the sitting height/stature ratio amongst the Negro, Navajo and Whites in U.S.A. at 19.0 years of age as 51.31, 53.31, 53·28 respectively. The Bengalees come closest to the Negroes in this respect.

The sitting height and stature indices for all the age groups from 9 to 17 years are higher as shown in Simmon's study for the Brush Foundation, than those in the Bengalee girls at the corresponding ages. Both Simmon's and Steggarda's findings show that the White girls of U.S.A. have a little higher sitting height in relation to stature than the Bengalee girls while the latter lie between the Whites and the Negroes.

Appleton's study on Chinese girls in Hawaii show that in general these girls have similar relative sitting height as the Bengalee girls but the ultimate age group of 20 years in the Chinese series has relatively higher sitting height (53%) than the Bengalee series (52%) at the same age. The length of the leg in Appleton's series is not comparable to that in the present series as landmarks differ.

The indices for the native Japanese girls studied by Greulich show proportionately much higher sitting height than the Bengalees, the Chinese and the Americans, for all the age groups concerned. The Japanese girls sit as high as 55% of their stature in their late teen ages.

To sum up, it may be said that the preadolescent spurt in stature in the present sample is contributed more by the lengthening of the legs than by the sitting height. Futher, the post-adolescent proportions of stature—legs and stature—sitting height undergo an oscillation and nearly go back to the pre-spurt stage.

On the other hand, the length of the upper limb in proportion to stature remains nearly stationary from 9 years to 20+ years of age, though a very slight increase in stature in comparison to upper limb length is noticed. Appleton's study on the Chinese girls of Hawaii also supports this finding. Figure 39 showing the arm length plotted against the stature bears out the

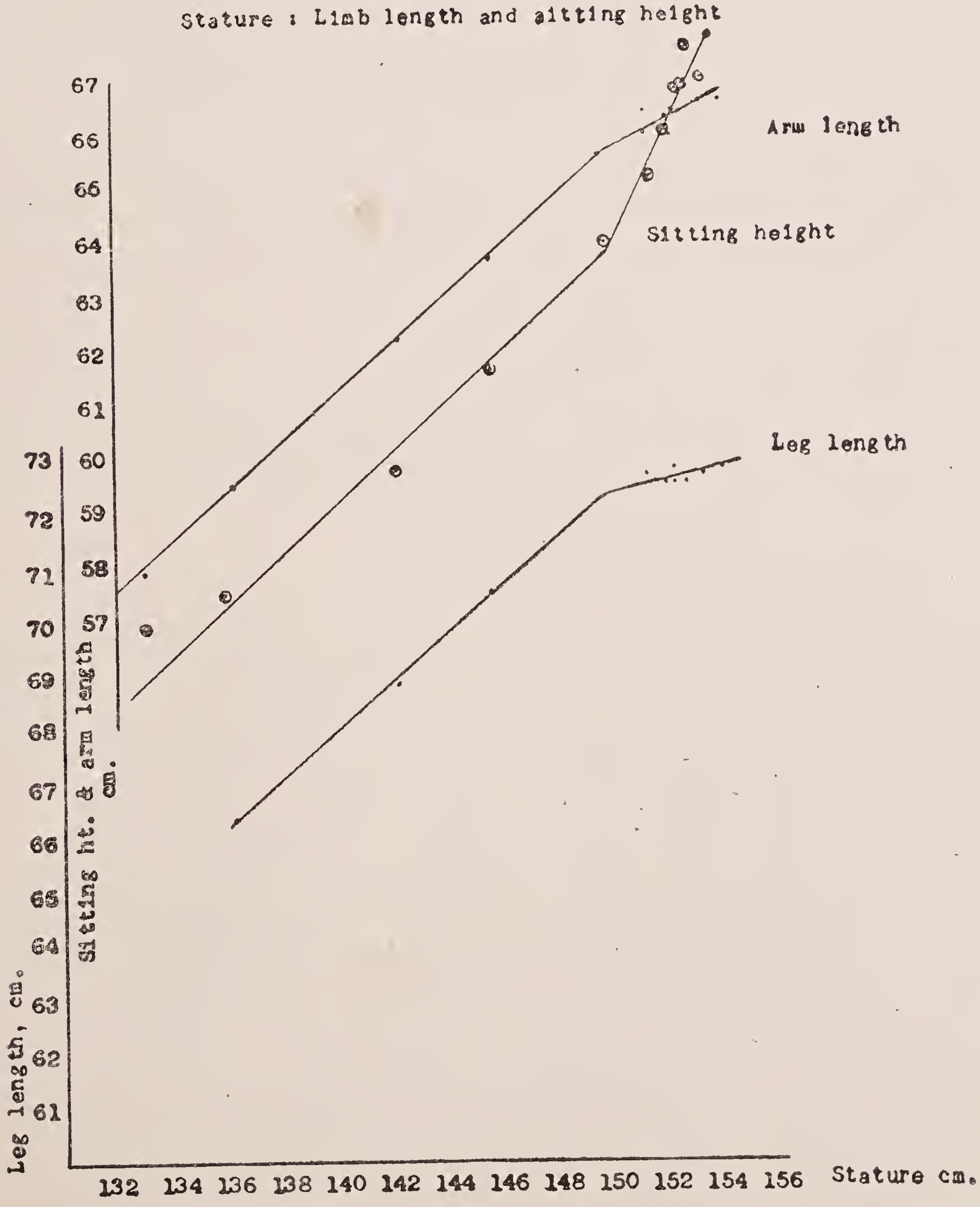


Fig. 39. Regression lines for sitting height and stature, arm length and stature, leg length and stature.

above conclusion. The arm length-line rises with the rise in stature-line and at the last stage the increment in arm length somewhat slows down in comparison with that of stature.

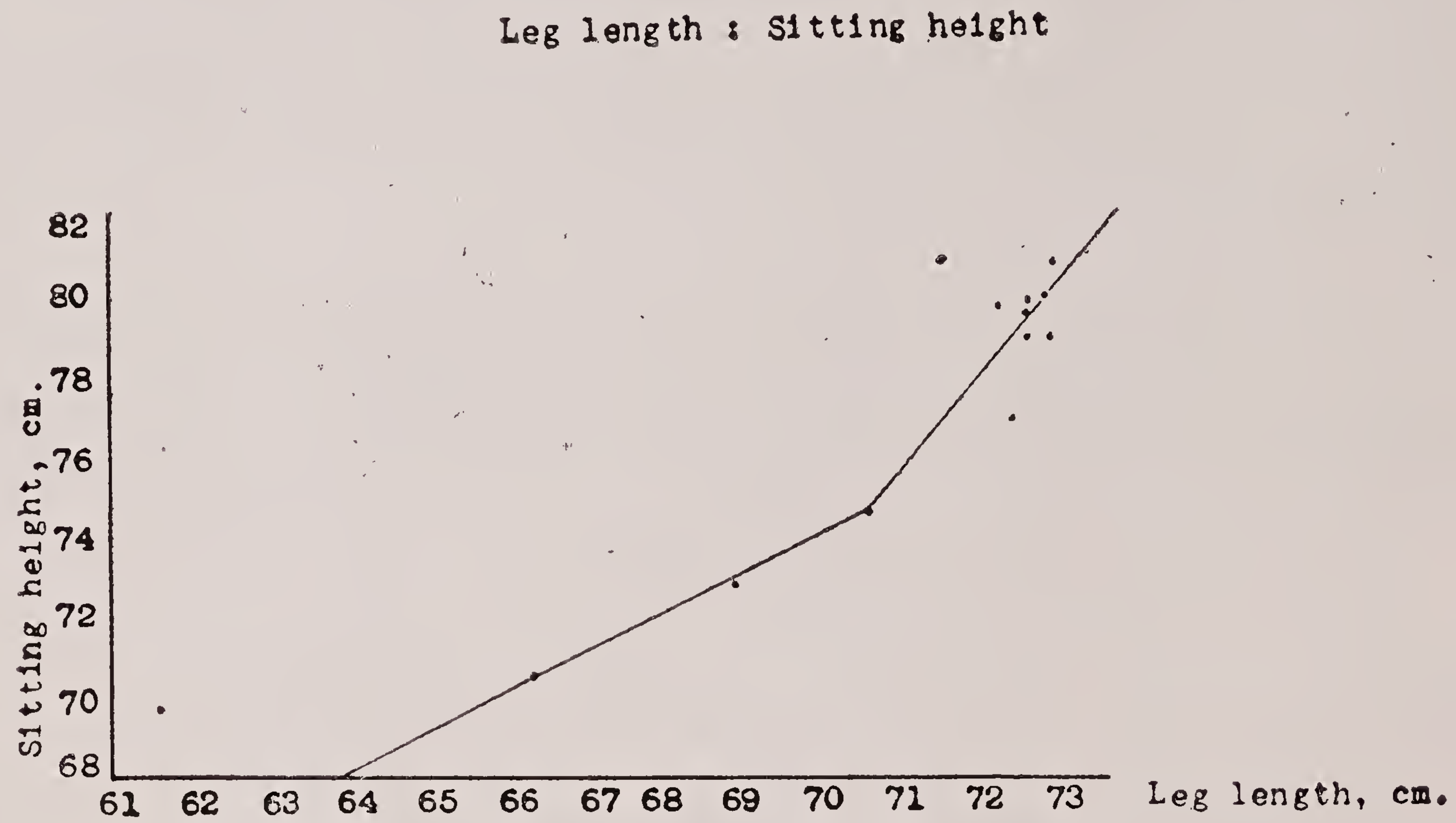


Fig. 40. Regression line for leg length and sitting height.

Lower limb and upper limb ...

$$\text{The arm-leg index} - \frac{\text{Length of the lower limb (cm)}}{\text{Length of the upper limb (cm)}} \times 100$$

The index showing the length of the leg (lower limb) in relation to the upper limb in each age group is given in Table XXXIII. The agewise distribution of this index from the table as well as from Figure 38 shows very clearly that the increase in the lower limb in comparison to the upper one is marked in between the 1st and the 2nd age groups but after this (10th year) the increase in upper limb is proportionately a little more than that in the lower. This position is maintained as a constant all along from 13 years of age onwards.

In Figure 41 are plotted the means of arm length against those of leg length. The slope in the line is steep, denoting a higher rate of increase in arm length compared to that in leg length. Both these dimensions have perceptibly stabilised when the leg length measures between 72 and 73 cms and the arm length between 66 and 67 cms.

Stature and breadth

The development corresponding to the advances in age, of the three transverse dimensions of the body—bi-acromial diameter, chest breadth and bi-iliac diameter in relation to stature is shown by the indices :

(1) $\dfrac{\text{Bi-acromial diameter (cm)}}{\text{Stature (cm)}} \times 100$ = relative shoulder breadth

(2) $\dfrac{\text{Chest breadth (cm)}}{\text{Stature (cm)}} \times 100$ = relative chest breadth

(3) $\dfrac{\text{Bi-iliac diameter (cm)}}{\text{Stature (cm)}} \times 100$ = relative hip breadth

(4) $\dfrac{\text{Bi-iliac breadth (cm)}}{\text{Bi-acromial diameter (cm)}} \times 100$ = acromio-iliac index

The three relative breadths give the values shown in Table XXXIV where also the values of the fourth index, giving the relative development of hip and shoulder according to age, are shown.

Leg length : Arm length

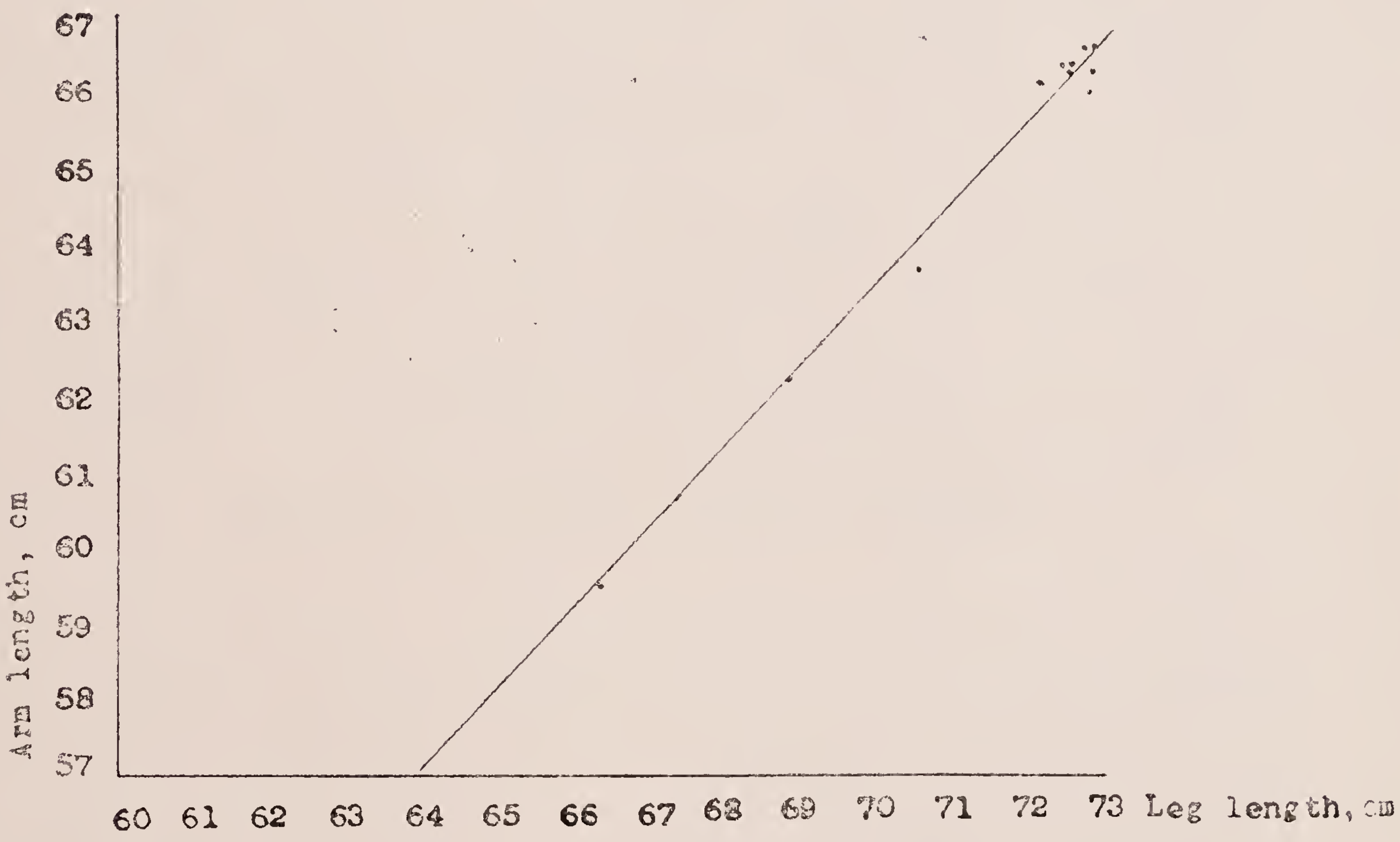


Fig. 41. Regression line for leg length and arm length.

These four indices have been plotted against each age group in Figure 42. The bi-acromial breadth in relation to stature show a very gradual rise from 9 to 18 years of age. After 18 the line runs horizontally showing no increase. The means of bi-acromial breadth plotted against those of stature in Figure 43 show the slope of the eye-estimated regression line to be very much inclined in the first segment, denoting slower rise in the bi-acromial breadth compared to the rise in stature. In the latter and smaller segment the line rises steeply which means that after the stature measures 152 cm the increase in bi-acromial breadth is faster than that in the stature.

Relative chest breadth, though it undergoes a setback at the initial stage (between 9 and 10 years of age), gradually rises from 10 years to the last age group. This rise is slow but steady. In Figure 44 the means of the chest breadth are plotted against those of the stature. Like the 'bi-

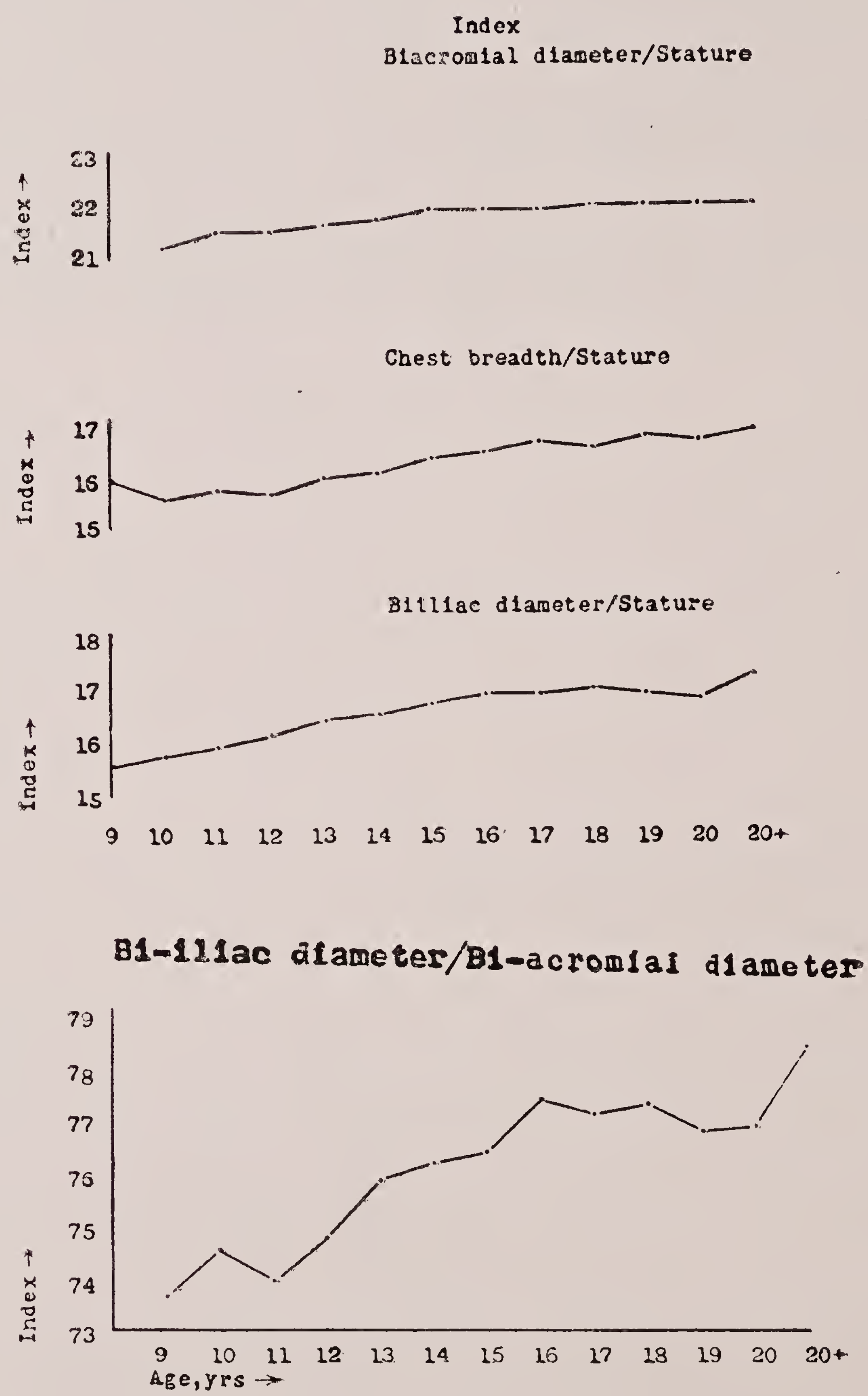


Fig. 42. Bi-acromial diameter/stature, chest breadth/stature, bi-iliac diameter/stature and bi-iliac diameter/bi-acromial diameter indices as the age changes.

acromial line' the 'chest breadth line' also is inclined but to a greater degree, which means that the increase in the chest breadth is comparatively slower than that in the stature. However, when the stature measures 150 cm the increment in chest breadth accelerates.

Relative hip breadth also shows slow and steady rise from 9 to 16 years of age. Thereafter it is nearly stable except at the last stage, e.g., from 20 years to 20+ years of age, which may be due to deposit of fat in the hip region giving higher values for bi-iliac diameter. The regression line for the hip breadth on stature in Figure 44 shows much similarity with that for the bi-acromial breadth and stature. The velocity of growth in the hip breadth shows linearity with that of the stature ; but in the latter this velocity is more intense than it is in the former. But when the stature reaches 152 cm the hip breadth shows more acceleration in its growth than the stature.

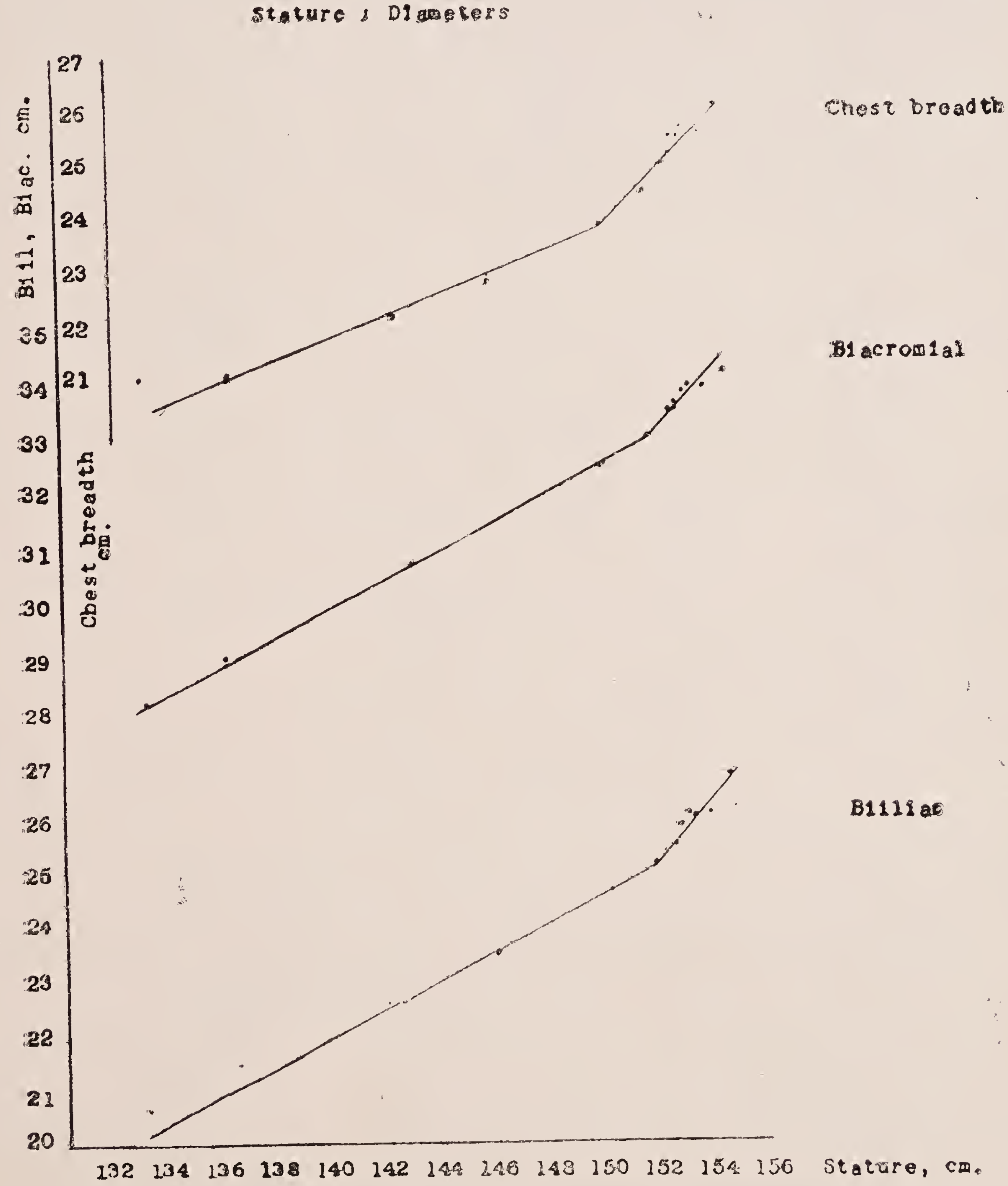


Fig. 43. Regression lines for stature and bi-acromial, bi-iliac and chest diameters.

In contrary to all the above three indices, the bi-iliac/bi-acromial breadth index increases very irregularly all along, the increase in the last age group being the maximum. As stated before,

Table XXXIV : Relative breadths according to age

Age in years mid-point	Bi-acromial / stature	Chest breadth / stature	Bi-iliac / stature	Bi-iliac / Bi-acromial
9	21.10	15.88	15.52	73.57
10	21.17	15.51	15.74	74.35
11	21.50	15.65	15.88	73.89
12	21.49	15.64	16.06	74.68
13	21.59	15.85	16.35	75.75
14	21.69	16.04	16.49	76.07
15	21.87	16.30	16.66	76.27
16	21.87	16.41	16.89	77.25
17	21.93	16.58	16.89	77.04
18	21.99	16.52	16.98	77.19
19	22.01	16.69	16.89	76.65
20	21.96	16.55	16.84	76.80
20+	22.04	16.81	17.26	78.31

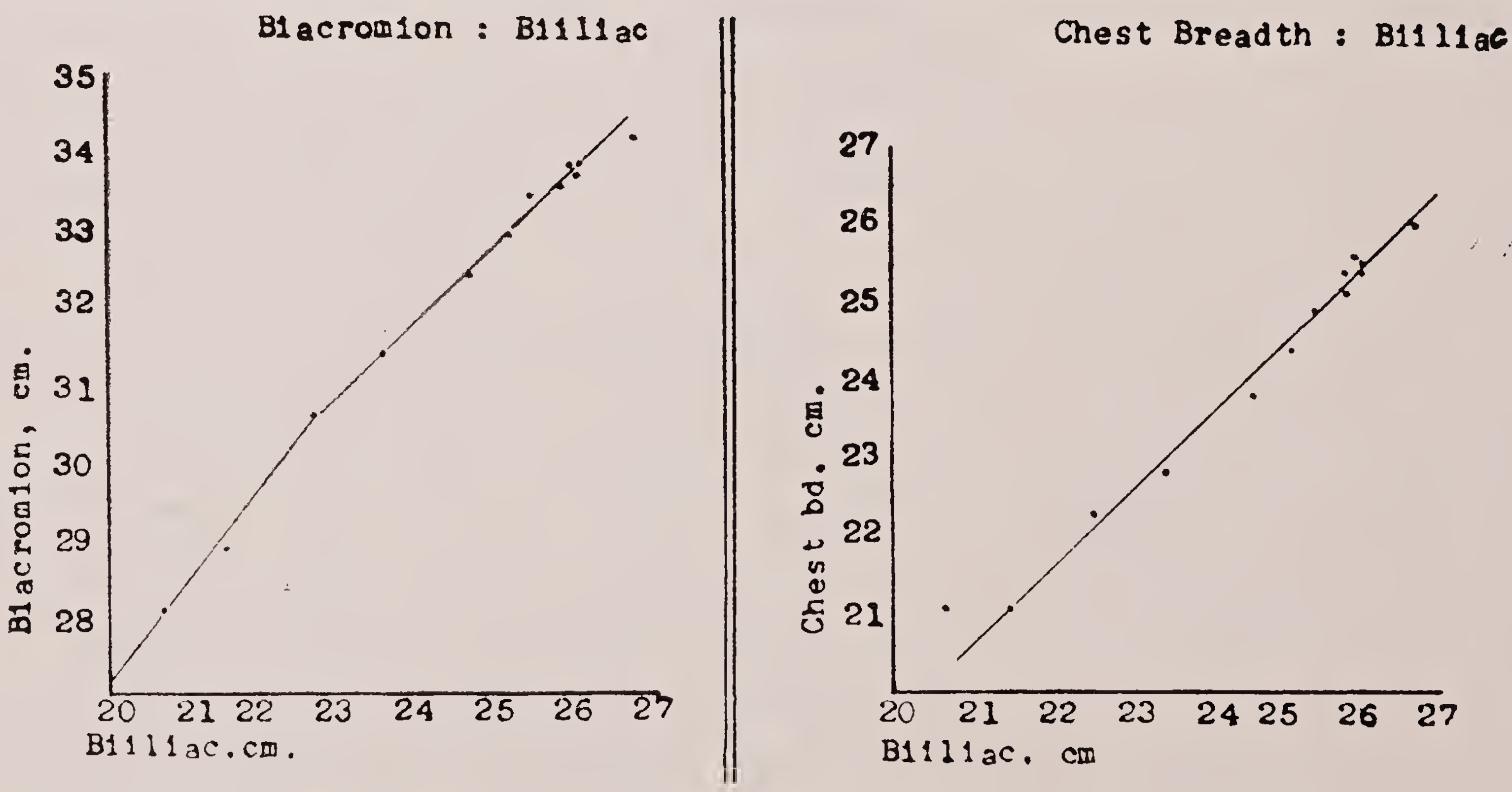


Fig. 44. Regression lines for bi-iliac and bi-acromial, bi-iliac and chest breadth.

the reason is the deposit of extra fat on the hip while the acromial region is mainly bony. The regression line between these two dimensions (Figure. 45) shows a wide angle at a point where bi-acromial breadth measures 30.5 and bi-iliac breadth 22.5 cm. Below this point of bend the two breadths increase at the same rate and beyond this point the increase in bi-iliac breadth is more in comparison with that in bi-acromial breadth. The relationship between chest breadth and bi-iliac breadth in Figure 44 is almost linear, during the growth period.

The trend of development in the relative bi-acromial width and bi-iliac width of this series shows similarity to those of the Weissenberg's (1911) Jews, Schultz's (1926) Whites and Negroes and Devenport's (1935) Nordic respectively.

To sum up, it can be said that the widening of the hip is much more pronounced than that of the shoulder as the age advances. The widening of the hip in relation to stature is most marked ; the widening of the chest in relation to stature comes next. In relation to stature the increase in the shoulder breadth is the least marked. This condition is noted up to the age of fifteen years ; but a near-stationary situation is reached at about 16 or 17 years of age in the girls in the present sample.

Other indices

The indices for girth and length, girth and weight have been worked out for the following dimensions :

$$\frac{\text{Chest girth (cm)}}{\text{Stature (cm)}} \times 100$$

$$\frac{\text{Circumference of upper arm (cm)}}{\text{Length of upper limb (cm)}} \times 100$$

$$\frac{\text{Circumference of calf (cm)}}{\text{Length of lower limb (cm)}} \times 100$$

$$\frac{\text{Weight (kg)}}{\text{Chest girth (cm)}} \times 100$$

Besides these, two more indices fat and stature and fat and weight have also been taken into account. The total fat is the total of the untransformed skinfold measurements of three areas (subscapular, upper arm and calf). The indices are :

$$\frac{\text{Total fat (mm)}}{\text{Stature (cm)}} \times 100$$

$$\frac{\text{Total fat (mm)}}{\text{Weight (kg)}} \times 100$$

All these six indices show the trend in the development of the body. Their values are given in Table XXXV.

The values of these indices are plotted against the respective age groups in Figures 45 and 47. The chest girth/stature index shows no increase between 9 and 10 years and a rapid increase between 10 and 15 years. Then the increase gradually slows down after 15 years of age. By the 17th year the increment in chest girth in proportion to stature stops.

Compared to the 20-year old Bengalee girls in respect of chest girth/stature index, the Negro, the Navajo and the White girls of the same age studied by Steggarda show the values of 49.30, 52.84 and 48.69 respectively.

The weight/chest girth index shows a very rapid increase in weight compared to that of the chest girth from 10 to 13 years of age. From 13 to 17 the relative increase in weight is smaller ; from 17 years onwards the relation between these two dimensions is almost steady, followed by a relative increment in weight after 20 years of age.

The two above mentioned indices show that the relative increment in chest girth is pronounced in pre- and post-pubescent ages. This continues up to 17 years of age after which it stabilises.

Table XXXV : Age variation in six indices

Age in years midpoint	Chest girth / stature	Arm girth / arm length	Calf girth / leg length	Weight / chest girth	Total fat / stature	Total fat / weight
9	46.38	30.76	41.57	42.84	2.29	11.53
10	46.43	29.56	38.99	43.05	2.02	10.05
11	47.05	29.84	39.70	48.39	2.32	10.20
12	48.64	30.23	39.80	49.41	2.29	9.68
13	49.20	30.82	40.85	53.65	2.52	9.56
14	49.68	31.66	41.66	54.18	2.65	9.87
15	51.06	31.56	42.24	54.66	2.70	9.67
16	51.38	32 29	42.50	55.39	2.82	9.91
17	51.62	32.75	42.90	55.55	2.83	9.87
18	51.10	32.45	42.79	55.65	2.88	10.13
19	51.32	32.63	42.69	55.72	2.87	10.03
20	51.09	32.90	42.66	55.62	2.83	9.94
20+	51 23	34.28	43.55	59.30	3.19	10.52

The upper arm circumference/total arm length index shows a relatively rapid increase in arm length between 9 and 10 years of age ; then from 10 to 17 years of age the arm girth increases relatively steadily and slowly. After 17 the relative arm girth does not increase except at the age between 20 and 20+ years. This relative increase in arm girth is probably due to more fat accumulation on the arm at this age while the length remains almost stationary.

The regression line between these two dimensions (Figure. 46) shows comparatively rapid increase in length than the girth till the length measures 65.6 cm then the line bend sharply upwards, denoting faster increase in girth in comparison to length.

The calf girth and leg length index (Figure. 45), like the preceding index, shows high values at 9 years followed by a sharp drop at 10 years, then a slow but steady rise on the whole up to 17 years of age. From 17 to 20 years there is no increase; but afterwards an incrase is noted though it is not as high as the arm girth/arm length index. The overall similarity in the changes of the two indices of arm and leg through the ages is marked. As the growth progresses the regression line (Figure. 46) for these two measu rements show the increase in both at the same

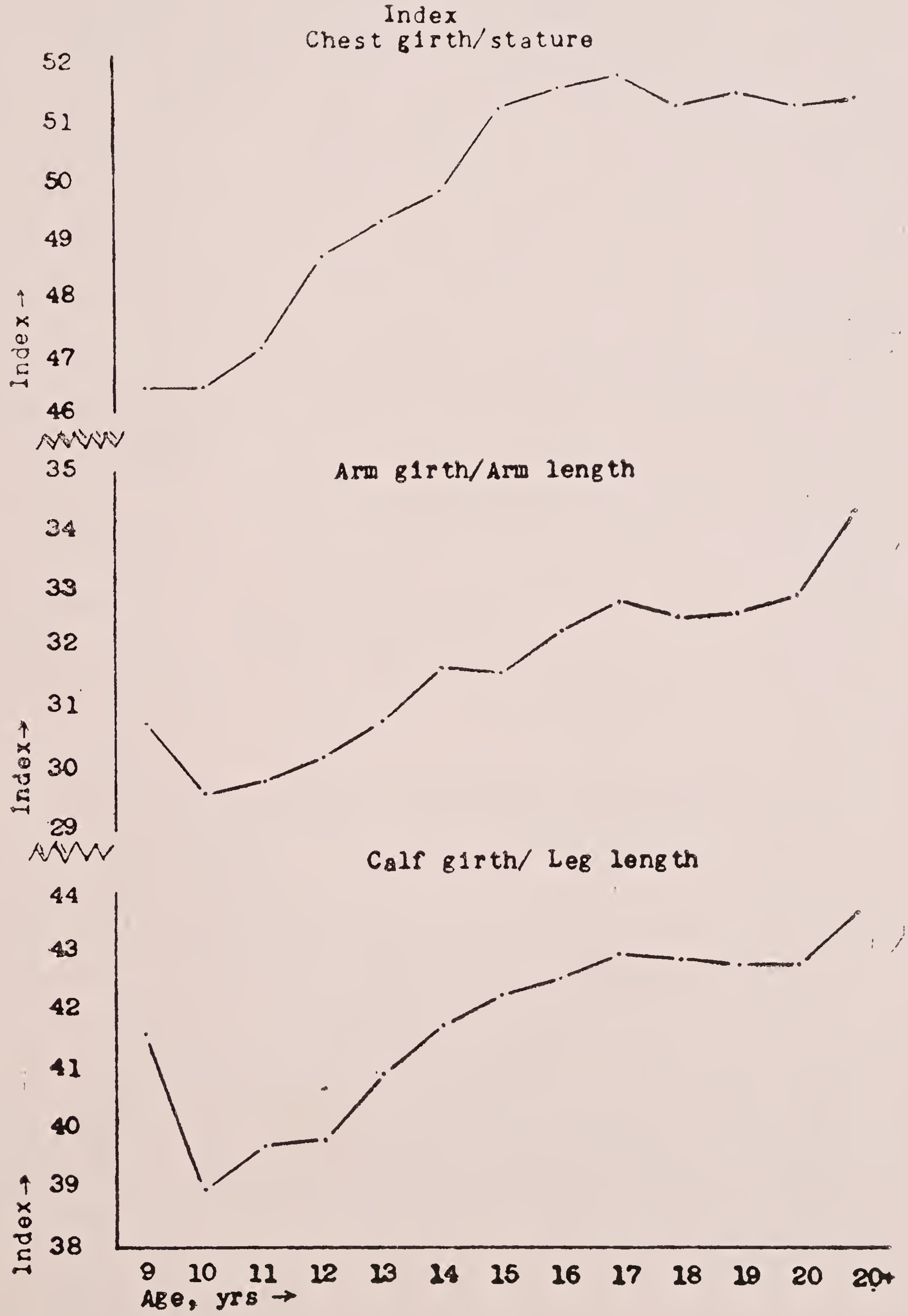


Fig. 45. Age changes in chest girth/stature, arm girth/arm length, calf girth/leg length indices.

rate till the length is 70.5 cm and the girth is 28.3 cm. After this the girth increases considerably faster than the length.

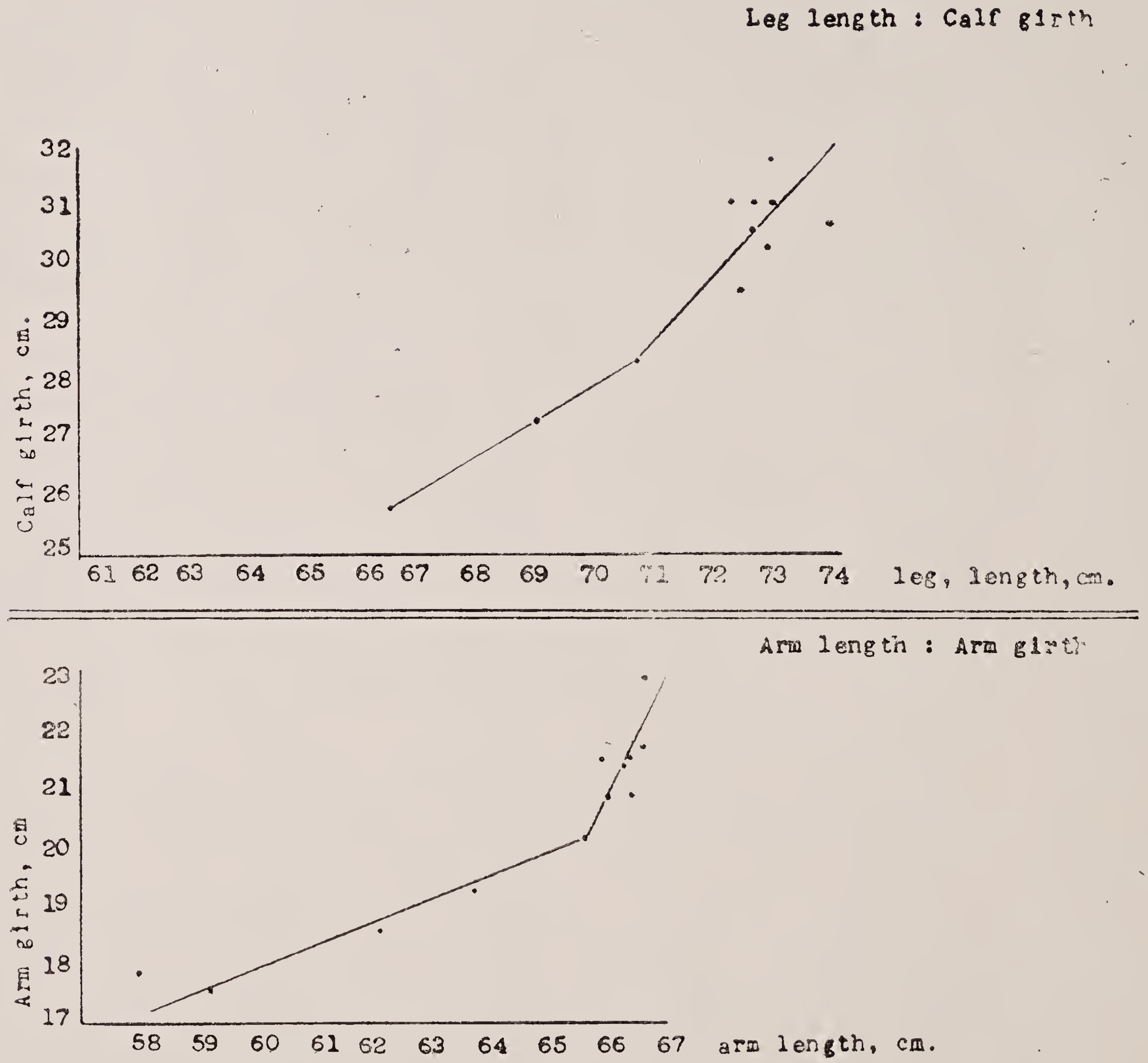


Fig. 46. Regression lines for leg length and calf girth, arm length and arm girth.

The last two indices deal with the fat deposit and stature or weight for each age group. The agewise fat deposit relative to stature is shown graphically (Figure. 47). The 'relative fat' drops from 9 to 10 years of age after which there is a very slow and nearly constant rise all along from 20 to 20+ age group the 'relative fat' rises notably.

The fat/weight index shows a big drop from 9 to 10 years of age. This drop is made up at the subsequent age groups. But in the fat/stature index the drop is far from made up. From 10 to 11 years there is a slight rise in the fat/weight index. Then the index registers a drop from 11

to 12 years. Thereafter an almost constant ratio is maintained, though a slight rise is marked between 20 and 20+ years. This rise is due to the pronounced fat deposit.

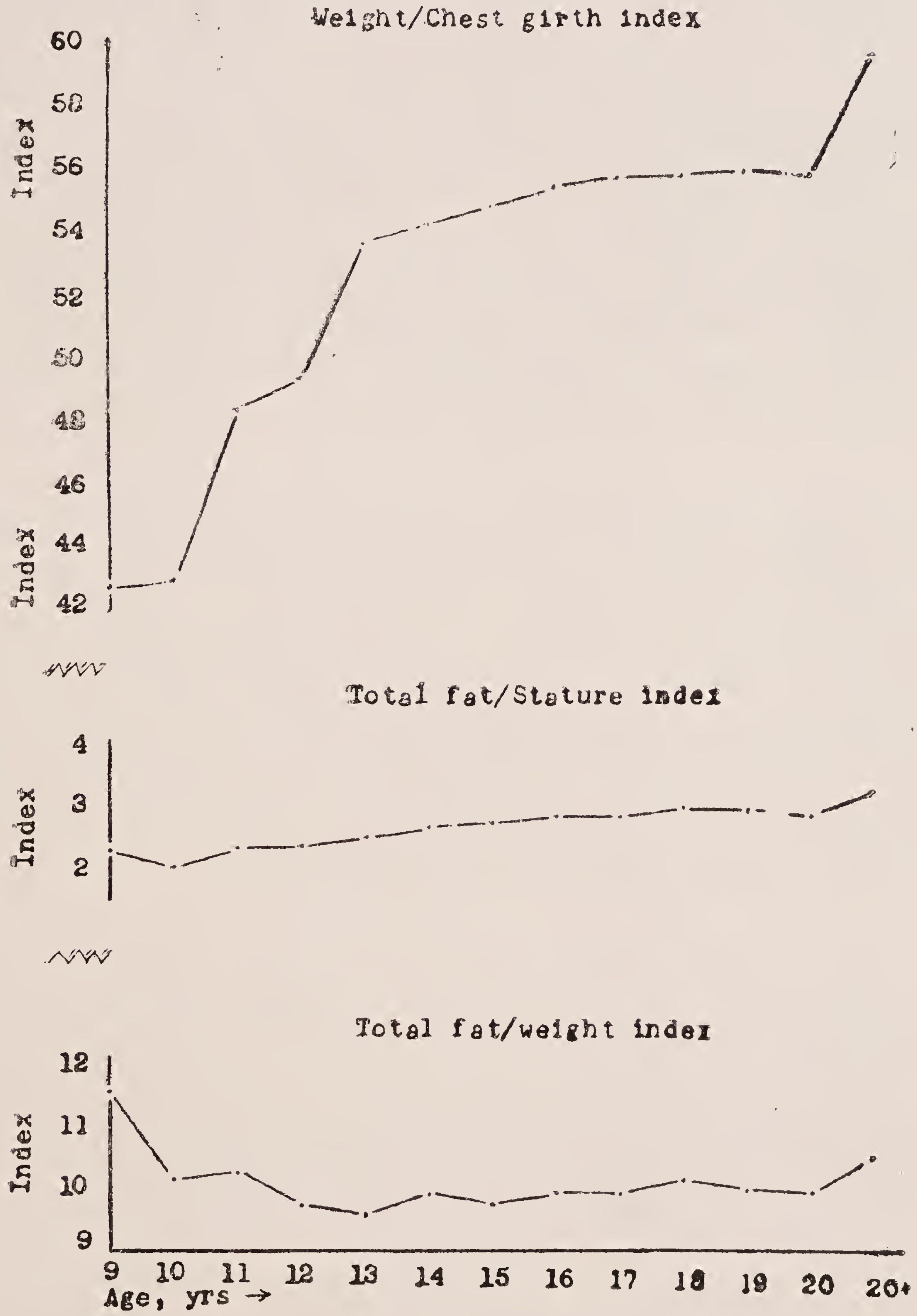


Fig. 47. Age changes in weight/chest girth, total fat/stature, total fat/weight indices.

SUMMARY AND CONCLUSION

An attempt has been made in the previous pages to give a descriptive account of the growth and development of 2536 Bengalee girls from several schools and colleges in Calcutta. The traits considered were : the age at menarche, the age at eruption of the permanent teeth, particularly the II and III molars. Among the linear measurements the stature, sitting height, length of limbs, the bi-acromial, bi-iliac and chest diameter were considered. The girths were measured at three sites—chest, upper arm and calf. The thickness of the subcutaneous fat at three sites—sub-scapular, upper arm and calf, was also measured. Finally, the body weight in kilogram was recorded.

The age of the subjects of the present sample ranged between 9 and 27 years, those above 20 being grouped together as 20+. There were therefore thirteen age groups. Year-by-year growth of all metric characters were shown in both appropriate tables and figures. Direct measurements formed the basis of the calculations of statistical constants of all metric characters except those of body weight and skinfolds. Since the distribution of these measures is non-Gaussian, logarithmic transforms of direct measurements were taken into account. In case of non-metric characters—namely, the age at menarche and the time of eruption of teeth—the mean of the entire sample was calculated together with their percentile incidence according to the age groups.

In addition to showing the age-by-age changes of metric traits—that is, the growth pattern of these Bengalee girls—each trait was compared with suitable materials from outside the country. Comparable Indian material is admittedly scanty. However, the characteristic growth pattern of the Bengalee girls becomes apparent only whenit is placed against the background of the available growth patterns of girls from other countries. An attempt is made here to give some idea of such a pattern as far as it is revealed by comparisons made in the foregoing pages.

The stature of the Bengalee girls of the present sample comes to 153 cm at the age of 17 years. At the same age, the American-born Japanese, East African, Harvard and Brush Foundation study of White girls have 154.8 cm., 156.6 cm., 159.3 cm and 165.2 cm respectively. The Bengalee girls thus are the shortest. This position was, however, not maintained throughout the growth period ; for at the age of 13 years the differences between the Bengalee values and those of the American-born Japanese, East African and Harvard White girls were much narrower, and the native-born Japanese were definitely shorter than the Bengalee girls. The Brush Foundation White American girls, however, are still very far above the Bengalees. Coming down fur-

ther to the initial age of 9 years, it may be observed that the situation becomes quite different. The Bengalees at this age have the mean height of 133 cm as compared to 127.4 cm and 128.5 cm for the Harvard White American and the East African girls respectively. The native-born Japanese girls are considerably below the Bengalees in the values. Even the Brush Foundation White American girls are only 2 cm taller than the Bengalees at the age of 9 years.

The reversal of the relative position of the Bengalees from the age of 9 to the age of 17 years may to a large extent be seen in sitting height and weight as well. Many of the groups which had lower values at the age of 9 years than the Bengalees, move up at the age of 17, leaving the latter at the bottom of the series. The same is true with regard to the growth of the lower and the upper limb lengths. However, the growth of transverse diameters of bi-acromial and bi-iliac does not show such reversals of position of the Bengalees relative to others. These two dimensions are uniformly smaller than others throughout the span of growth period considered here.

Now, this reversal of relative position in the vertical dimensions of the Bengalee girls is associated with two factors. First, the occurrence of early menarche in the Bengalee girls : the relatively early and high rate of growth of the dimensions proceeds for about a half-year after menarche, and then it slows down considerably. As a consequence, the growth lines take a wide bend prior to an almost stabilized and horizontal movement. Second, the slopes of the growth curves of the Bengalees from the age of 9 to 13 years are found to be more slanting than those of the others. This obviously indicates that not only the growth process is retarded at a relatively early age due to the early menarche of these girls, the growth rates too from 9 years of age are slower than those of the girls of the other comparable samples.

The mean age at menarche of the present sample is 12.48 years. This mean age does not show much of a change in last one hundred years as revealed by the data published so far. This static condition of the menarcheal age is perhaps due to the static condition of the socio-economic life of this society.

The close relationship between the growth spurts and the age at menarche has been seen clearly in the present work. The agewise growth spurt has been examined with reference to the distribution of standard deviations of the mean values of different dimensions. The increment of these values closely correspond to the increment of mean values of the dimensions at a given age. In most of the dimensions, the age at menarche is related to the spurt. It the majority of the cases, again, the peak of the spurt is about one and a half years prior to the menarcheal age. It has also been seen that the mean age at the eruption of the II molars (i.e. the age of 14 years) coincides with the slowing down of the velocity of growth in almost all dimensions.

The present work has thrown up two problems which need further investigation. First, it may be seen that the girls of the present series quite appreciably rise in stature even after 18 years of age. The problem is to determine the age at which dimensions, especially linear, stop growing

at all—an age when an individual may be said to attain physical adulthood. It may be mentioned that this is not only the case with the present sample, but as has been stated earlier, all workers in this field who have measured girls in other countries of ages beyond 20 years have the same finding though only a few have made specific reference to it.

The second problem is that, almost consistently the Bengalee girls show lower values in all dimensions of body when compared to foreign girls throughout the range of the ages covered, except at the initial age of 9 and 10 years, when the Bengalees occupy a better status. It is rather that something has happened to these girls after the age of 10 years to cause considerable retardation in vertical as well as the general overall growth, although before the age of 10 years the growth rate is more favourable. Besides the adolescent spurt, there is the juvenile spurt which generally takes place between the ages 6 and 8 years. Now, the relatively higher position of the Bengalee girls in the initial periods may depend upon this juvenile spurt which is expected to be quite high. But no record of the growth processes in the Bengalees at this crucial age is available. Obviously the rate of growth together with the absolute size at infancy and early childhood in the Bengalee girls are both higher than the corresponding characteristics in the foreign girls. This phenomenon can hardly be explained as due to a lower nutritional status. On the other hand there is an indication to suppose that there is a distinct genetical pattern of the growth processes in the Bengalees. Nothing definite can be said about this phenomenon until further work is done. An examination of the growth process from birth to 10 years in the Bengalee girls may throw some light.

It is thus seen that even on a purely descriptive level there is much work to be done on growth studies in this country. There is no doubt that longitudinal growth studies lead to a better understanding of growth rates and are more accurate than the cross-sectional ones, as is the present one. While the present investigator recommends such studies, she holds the view that cross-sectional studies for the entire growing period for the Bengalee girls are of immediate necessity. These studies enable one to identify and comprehend problems relating to the pattern of growth. Should circumstances permit, such studies may be followed up more intensively by the time-consuming and expensive longitudinal method.

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